DOCUMENT RESUME

ED 159 000 SE 024 739

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|---|---|
| TITLE | Using Pesticides: Commercial Applicator Manual, Texas. Agricultural Pest Control - Field Crop Pest Control, Fruit and Vegetable Pest Control, Weed and Brush Control. |
| INSTITUTION | Texas A and M Univ., College Station. Texas Agricultural Extension Service. |
| PUB DATE | [77] |
| NOTE | 167p.; For related document, see SE 024 738; Contains occasional small, light and broken type |
| EDRS PRICE | MF-$0.83 HC-$8.69 Plus Postage. |
| DESCRIPTORS | *Agricultural Production; Disease Control; Environment; Equipment; *Instructional Materials; *Job Skills; *Legislation; *Pesticides; Post Secondary Education; Public Health; *Safety |
| IDENTIFIERS | *Commercial Applicators; Pest Control; Texas |

ABSTRACT

This document is designed to provide commercial pesticide applicators with practical information and regulations required by the Texas Department of Agriculture. The manual includes two major sections. The first section discusses labels and labeling, pesticides, aerial application, ground application, pesticide safety, pests and pest damage, environmental considerations, and certification requirement for commercial and noncommercial applicators. The second section discusses agricultural pest control which includes four topics of field crop pest control, fruit and vegetable pest control, weed control, and weed and brush control. Some review questions are presented at the end of each topic. The manual also presents some selected references. (HM)

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# Using Pesticides

## Commercial Applicator Manual

## AGRICULTURAL PEST CONTROL

FIELD CROP PEST CONTROL
FRUIT AND VEGETABLE PEST CONTROL
WEED AND BRUSH CONTROL

## Texas

SE 024 739

Texas Agricultural Extension Service · The Texas A&M University System

Daniel C. Pfannstiel, Director · College Station, Texas

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RECEIVED 4/25/77

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# THE CERTIFICATION REQUIREMENT
# COMMERCIAL AND NONCOMMERCIAL APPLICATORS

Significant changes in federal and state laws during the past few years affect you as a commercial pesticide applicator. The changes, for the first time in the history of federal law regulating pesticides, regulate pesticide use. State law, once regulating only herbicide use in certain counties, has likewise been changed to include regulation of all pesticide use. As a pesticide applicator you may wish to become familiar with all provisions of these new laws.

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), first passed in 1947 following discovery of synthetic organic pesticides, was amended significantly in 1972 by the Federal Environmental Pesticide Control Act. The act, further amended in November 1975, is administered and enforced by the Environmental Protection Agency (EPA).

A pesticide is any substance or mixture of substances intended to prevent, destroy, repell or mitigate any pest and any substance or mixture of substances prepared for use as a plant regulator, defoliant or desiccant. The types of pesticides include: insecticides to control insects and other related pests, such as ticks and spiders; fungicides to control fungi; herbicides to control weeds; rodenticides for controlling rodents and predicides to control vertebrate pests. Other pesticides include nematicides, bactericides, avicides (for controlling birds), molluscicides (for controlling mollusks, such as snails and slugs), piscicides (for fish control), etc.

Pesticides sold, offered for sale, distributed or delivered for transportation, or transported within the state must be registered with the Texas Department of Agriculture (TDA) and with the EPA. Federal registration applies within the state, but additional state and local restrictions may exist.

Federal law requires the EPA to classify each use of a pesticide as either restricted or general. A federally restricted-use pesticide may be used only by or under the direct supervision of a certified applicator. The state may further restrict additional uses to certified applicators or impose other restrictions.

The Texas Pesticide Control Act (TPCA) repeals and replaces the Insecticide, Fungicide and Rodenticide Act of Texas. Among other features, it incorporates certification requirements of commercial applicators as mandated by federal law. The state law also establishes an additional category of pesticide applicators--the noncommercial pesticide applicator. The Texas pesticide control regulations further define the requirements of the Texas Pesticide Control Act. The TDA is designated as the lead agency for developing and implementing the State of Texas Plan for Certification of Pesticide Applicators.

A commercial applicator is in the business of applying, using or supervising the use of a restricted-use or state-limited-use pesticide to the property of another for hire or compensation.

A noncommercial applicator as established by the Texas Pesticide Control Act is "a person or government agency or department which wants to use restricted-use or state-limited-use pesticides and does not qualify as a private applicator and is not required to have a commercial applicator license."

The noncommercial applicator as designated under state law is a commercial applicator under federal law. Commercial and noncommercial pesticide applicators must meet the same certification standards. The federal regulation requires satisfactory completion of a written examination and, as appropriate, performance testing. All commercial and noncommercial applicators must demonstrate a practical knowledge of pest control and safe use of pesticides.

Under state law a private applicator uses or supervises the use of any restricted-use or state-limited-use pesticide for producing any agricultural commodity on property owned or rented by him or his employer or under his general control; or if applied without compensation other than trading personal services between producers of agricultural commodities on the property of another person. The private applicator, although subject to the certification requirement and other provisions of the Federal Insecticide, Fungicide, and Rodenticide Act, is not required by the Texas Pesticide Control Act to have a license or be certified to use restricted-use or state-limited-use pesticides.

The Structural Pest Control Board regulates persons engaged in the structural pest control business and includes persons who engage in, offer to engage in, advertise for, select or perform any of the following:

. Identifying infestations or making inspections for the purpose of identifying or attempting to identify infestations of:

  - Arthropods (insects, spiders, mites, ticks and related pests), wood-infesting organisms, rodents, weeds, nuisance birds and any other obnoxious or undesirable animals which may infest households, railroad cars, ships, docks, trucks, airplanes or other structures or the contents thereof

  - Pests or diseases of trees, shrubs or other plantings in a park or adjacent to a residence, business establishment, industrial plant, institutional building or street

. Making inspection reports, recommendations, estimates or bids, whether oral or written, regarding infestations

. Making contracts or submitting bids for, or performing services designed to prevent, control or eliminate such infestations with insecticides, pesticides, rodenticides, fumigants or allied chemicals, substances or mechanical devices

The Texas Structural Pest Control Act requires certification and licensing of persons engaged in the business of structural pest control to use or supervise the use of all pesticides *regardless of use classifications*. The requirement became effective October 1, 1976. The person certified and licensed under

provisions of the Texas Structural Pest Control Act and offering services only in the license categories of structural pest control is not subject to the certification and licensing requirements of the Texas Pesticide Control Act.

The Texas Department of Agriculture will certify private applicators on a voluntary basis who wish to apply restricted-use pesticides in compliance with federal law.

TDA will certify and license commercial and noncommercial applicators in the license categories and subcategories as follows:

- Agricultural pest control
  - Field crop pest control
  - Fruit and vegetable pest control
  - Weed and brush control
  - Predatory animal control
  - Farm storage pest control
  - Fumigation
- Forest pest control
  - Insect and disease control
  - Weed and Brush control
- Ornamental and turf pest control
  - Plant pest control
  - Greenhouse pest control
  - Weed control

Additional categories are:

- Seed treatment
- Right-of-way pest control
- Regulatory pest control (for any and all categories and subcategories)
- Demonstration and research pest control (for any and all categories and subcategories)

The Texas Animal Health Commission will certify and license commercial and noncommercial applicators in the license category of animal pest control in the following subcategories:

- Tick, louse and mite control
- Fly control

The Texas Water Quality Board will certify and license commercial and noncommercial applicators in the license category of aquatic pest control in the following subcategories:

- Aquatic plant control
- Aquatic animal control

The Texas Department of Health Resources will certify commercial and

noncommercial applicators in the category of health related pest control in the following subcategories:

- Vector control
- Rodent control
- Sanitation

Commercial and noncommercial applicators will be certified on the basis of a test administered by the appropriate regulatory agency. Subject matter covered by the testing must include labeling and labeling comprehension, safety, environment, pests, pesticides, equipment, application techniques, laws and regulations and information as may be unique and necessary as related to the specific category or subcategory of applicator. Applicants for certification as commercial and noncommercial licensees will pay the certifying agency a nonrefundable testing fee of $10 for each test taken. Training is not a certification requirement for commercial or noncommercial applicators and is not a part of the official certification process.

Under state law no person, except an individual acting under the direct supervision of a certified applicator, may use or supervise the use of any restricted-use or state-limited-use pesticide unless he is licensed as a certified commercial or noncommercial applicator and is authorized by his license to use restricted-use and state-limited-use pesticides in the license-use categories covering his proposed pesticide use. The annual license fee for a commercial applicator is $75. For a nongovernmental, noncommercial applicator the annual license fee is $50. No fee is charged for a license issued to a governmental entity.

Commercial and noncommercial applicator licenses expire December 31 of the year in which it is issued. A person holding a current valid license may renew the license annually without retesting by paying the license fees. However, as determined by the regulatory agency upon consideration of technological changes in the use of pesticides, it may be necessary to pass a new examination or attend an approved training program for license renewal. Failure to file and pay for a license renewal by March 1 of any year requires passing the appropriate examination for recertification. If a license is issued in the name of a business, the business must have a certified applicator employed at all times. Before issuance of the license, the applicant must file evidence of financial responsibility consisting either of a bond executed by the applicant as principal or a liability insurance policy protecting persons who may suffer damages as a result of the operations of the applicant, the surety bond or insurance must be approved by the regulatory agency. Amount of the bond or liability insurance required for each license is $10,000 property damage, $20,000 aggregate and $10,000 bodily injury for each piece of aerial application equipment. The requirement for each piece of ground application equipment and hand-operated equipment is $5,000 property damage, $10,000 aggregate and $5,000 bodily injury. All insurance policies must include chemical drift coverage with amounts stated above for all pesticides to be applied. If the applicant's record indicates that more coverage is needed, the licensing agency may require additional coverage as necessary within the maximum limits established by the Texas Pesticide Control Act. The requirement for proving financial responsibility does not apply to the noncommercial applicator.

All licensed commercial and noncommercial applicators must maintain a record of all uses of restricted-use and state-limited-use pesticides for a period of 2 years. Records must include:

- Date of application
- Person for whom the work was done (owner or leasee)
- Location of the land where application was made stated to permit inspection by authorized parties
- Name of the pesticide and amount used
- Name of the pest for which it was used
- What was treated, i.e., name of crop, kind of animal, etc.
- Wind direction and velocity

The regulatory agency may examine these records at any time during normal business hours or by written request require the licensee to submit a copy of these records.

All application equipment used by commercial applicators must be registered with the licensing agency. The agency will issue a decal to the licensee which must be attached to each piece of equipment in a conspicuous place. All application equipment used by commercial applicators is subject to inspection by the regulatory agency at any reasonable time. Such equipment must be maintained in a condition that will provide safe and proper pesticide application. The licensee must notify the regulatory agency of any equipment changes made during the license year and remove the decal before giving up possession of the equipment.

Application of a restricted-use pesticide may be made by an individual under the direct supervision of the commercial or noncommercial applicator. Direct supervision is defined by the EPA as including verifiable instruction to include detailed guidance for applying the pesticide properly and provisions for contacting the certified applicator in the event he is needed. In some situations, as required by the label, the actual physical presence of the certified applicator may be required.

Among the requirements of federal and state law is the provision that use inconsistent with the label directions is a violation of the law and may subject the user to penalties under federal and state law.

The head of a regulatory agency which licensed a certified applicator may suspend temporarily for not more than 10 days, after written notice of noncompliance, and after opportunity for a hearing not less than 10 days after issuance of written notice to the licensee of the time, place and nature of the hearing, may suspend, modify or revoke any provision in the license of a certified applicator if he finds that the licensee has committed any of the following acts, each of which is a violation of the act.

- Made a pesticide recommendation or application inconsistent with the labeling or use restrictions of the pesticide imposed by the EPA or the state

- Operated in a faulty, careless or negligent manner

- Refused or, after notice, failed to comply with any applicable provision of the act, the rules and regulations adopted as provided in the act or any lawful order of the head of a regulatory agency by which he is licensed

- Refused or neglected to keep and maintain the required records or to make reports when and as required

- Failed to maintain a bond or insurance policy as required by the act

- Made false or fraudulent records, invoices or reports

- Used fraud or misrepresentation in making an application for, or renewal of, a license

- Aided or abetted a licensed or unlicensed person to evade provisions of the act, conspired with a licensed or unlicensed person to evade provisions of the act or allowed his license to be used by another person

In addition to revocation, modification or suspension of a license, a licensee committing any of the above acts is subject to the other penalty provisions of the act.

A person whose application for a commercial or noncommercial applicator license has been denied, revoked, modified or suspended for more than 10 days may appeal the action of the commissioner or head of a regulatory agency by filing an appeal in the district court of the county of his residence or in the district court of Travis County, within 30 days of the date of denial, revocation, modification or suspension. A copy of the notice of appeal shall be delivered to the person whose action has been appealed.

Any person claiming damages from a pesticide application may file a written statement claiming that he has been damaged. To be eligible for consideration by the regulatory agency which licensed the certified applicator whose action allegedly caused damage, the report must be filed within 30 days of the alleged occurrence, or if a growing crop is alleged to have been damaged, the report must be filed before 25 percent of the crop has been harvested or within 30 days, whichever is less. The report must contain, but is not limited to, the name or the owner or leasee of the land on which the crop is grown and for which damage is alleged to have occurred.

Upon receipt of a report, the regulatory agency must notify the licensee and the owner or leasee of the land on which the alleged acts occurred, and any other person who may be charged with responsibility for the damages claimed. The regulatory agency must inspect damages whenever possible and report its findings to the person claiming damage and to the person alleged to have caused the damage.

If damage is alleged to have occurred, the claimant shall permit representatives of the regulatory agency and the licensee to observe within reasonable hours the land or nontarget organism alleged to have been damaged, so the damage may be assessed.

Penalties for commercial applicators under the Federal Insecticide, Fungicide, and Rodenticide Act may be a civil penalty up to $5,000. Knowingly violating provisions of FIFRA is a misdemeanor. Upon conviction, a commercial applicator is subject to a fine of not more than $25,000 or imprisonment for not more than 1 year or both.

Penalties under the Texas Pesticide Control Act may include loss of certification or conviction of a Class C misdemeanor. Upon conviction, the maximum penalty for a Class C misdemeanor is $200. Each violation is a separate offense.

The Texas herbicide law regulates the sale of, and in some counties the use of, hormone-type herbicides. Permits are required in regulated counties for applying hormone-type herbicides to 10 or more acres.

Pesticides must be stored in a manner that will reasonably insure that human food, domestic and public water, pet foods, drugs, animal feeds, commercial fertilizers, seeds or clothing will not be contaminated.

The law also directs that pesticide containers are to be disposed of as directed on the label or by any other method approved by the Texas Department of Agriculture.

A tolerance, usually expressed in parts per million, is that amount of pesticide that may safely remain in or on a raw agricultural commodity. Tolerance enforcement is the responsibility of the Food and Drug Administration (FDA) under the authority of the Food, Drug, and Cosmetic act and of the Texas Department of Health Resources under authority of the State Food, Drug and Cosmetic Act.

The federal enforcement of tolerances for residues in meat and meat products is the responsibility of the Meat Inspection Division of the United States Department of Agriculture. A pesticide used according to label directions results in a chemical residue, if any, within the established tolerance.

Abiding by the law is everyone's responsibility. It assures continued availability of pesticides and protects ourselves and others and the environment.

Some of the legal responsibilities of the certified commercial and noncommercial applicator have been considered briefly. A copy of the Texas Pesticide Control Act and regulations is included in the packet of material you will receive as a part of this program activity. You also may wish to become familiar with the Federal Insecticide, Fungicide, and Rodenticide Act and applicable regulations.

## REVIEW QUESTIONS

### LAWS

1. Pesticides sold, offered for sale, distributed or delivered for transportation or transported within the state must be registered with the

   a) Texas Department of Agriculture
   b) Texas Water Quality Board
   c) Texas Department of Health Resources
   d) Environmental protection Agency

2. A federally restricted-use pesticide may be used only by or under the direct supervision of a

   a) certified private applicator
   b) certified commercial or noncommercial applicator
   c) pesticide dealer
   d) pesticide manufacturer

3. All licensed commercial and noncommercial applicators must maintain a record of all uses of restricted-use and state-limited-use pesticides for a period of

   a) 1 year
   b) 3 years
   c) 5 years
   d) 2 years

4. Records of uses of restricted-use and state-limited-use pesticides maintained by all licensed commercial and noncommercial applicators must include among other information

   a) date of application
   b) name of pesticide and amount used
   c) what was treated, i.e.: name of crop, kind of animal, etc.
   d) name and address of the manufacturer of the pesticide

5. Commercial and noncommercial applicators' licenses expire

   a) August 31 of the year in which it was issued
   b) December 31 of the year in which it was issued

6. Penalties for commercial applicators under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) for knowingly violating provisions of FIFRA include upon conviction

   a) a fine of up to $5,000
   b) suspension of certification for a period of 30 days
   c) a fine of not more than $25,000 or imprisonment for not more than one year or both

## LABELS AND LABELING

Another requirement of the federal regulation establishing the standards for certification of commercial applicators is a knowledge of pesticide labels and labeling.

A pesticide label is an end product of discovery, research, development and the federal and state registration process. Labeling requirements are part of registering a pesticide with EPA and the Texas Department of Agriculture. Federal law defines the label as the written, printed or graphic matter on, or attached to, the pesticide or any of its containers or wrappers.

Labeling includes the label and other information such as brochures, flyers and other materials referenced on the label or accompanying the label at any time.

What can we learn from the pesticide label? Certain information and its placement on the label is required by law. The product or brand name generally is the most prominent wording on the label. (See next page)

The active ingredient is identified by common or chemical name, or both, along with the amount. The active ingredient prevents or destroys pests and is responsible primarily for the desired effect. A product may contain more than one active ingredient. The remaining ingredients are collectively called inert ingredients. Such a mixture is generally called a formulation.

The active ingredient and the total of the inert ingredients are given by percentages. Additional information may be provided regarding the active ingredient such as the number of pounds of active ingredient per gallon of formulation.

Net contents must be shown in U.S. units and may also be given in metric units.

The label also must include the EPA registration number and an EPA establishment number. The latter number identifies the factory that made the product. The company's name and address also must appear on the label.

Thus far we have considered information relating to product identity. Labels tell us a lot more--things we need to know if we are to use a product effectively--including directions for use, statement of classification, physical or chemical hazards, environmental hazards, hazards to humans and domestic animals, a statement of practical treatment, a signal word and precautionary statements.

Pesticides are toxic. An estimate of the product's toxicity is provided by signal words. The signal word "DANGER" identifies a highly toxic product.

Highly toxic pesticide products also must carry the skull-and-cross-bones symbol. If a product is highly toxic as evidenced by the signal word "DANGER", a section informing physicians of the proper treatment for poisoning is included on the label.

## PRECAUTIONARY STATEMENTS

### HAZARDS TO HUMANS (DANGER)

Poisonous by swallowing or inhalation. Do not breathe spray mist. Do not get in eyes. Avoid contact with skin. Wear a mask or respirator of a type passed by the Mining Enforcement Safety Administration and the National Institute for Occupational Safety & Health for De Pesto protection. For emergency assistance call 000-000-0000

TO PHYSICIAN: De Pesto is a reversible cholinesterase inhibitor. Do not use oximes such as 2-PAM. Give Atropine 2mg. intravenously or subcutaneously. If in eye instill one drop of Homatrophine.

### ENVIRONMENTAL HAZARDS

This product is toxic to fish, birds and other wildlife. Birds feeding on treated areas may be killed. Keep out of any body of water. Do not apply where runoff is likely to occur. Do not apply when weather conditions favor drift from areas treated. Do not contaminate water by cleaning of equipment or disposal of wastes. This product is toxic to bees and should not be applied when bees are actively visiting the area.

### PHYSICAL OR CHEMICAL HAZARDS

Flammable! Keep away from heat or open flame

## DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

## RE-ENTRY STATEMENT

Do not enter area within five days after application

## CATEGORY OF APPLICATOR

For use only by agricultural pest control applicators.

## STORAGE AND DISPOSAL

STORAGE - Store in original container. Do not store next to food, water or feed or other articles intended for consumption by humans or animals.

DISPOSAL - Destroy by burying in a safe place.

OR

Contact Local, State or Regional Federal Authorities for local restrictions on disposal.

# RESTRICTED USE PESTICIDE

FOR RETAIL SALE TO AND APPLICATION ONLY BY CERTIFIED APPLICATORS OR PERSONS UNDER THEIR DIRECT SUPERVISION

# DE PESTO

**INSECTICIDE**
**EMULSIFIABLE CONCENTRATE**

| | |
|---|---|
| ACTIVE INGREDIENT: pestoff–tri-salicylic acid | 45.0% |
| INERT INGREDIENTS: | 55.0% |
| TOTAL: | 100.0% |

THIS PRODUCT CONTAINS 4.0 LBS OF PESTOFF PER GALLON

SPECIMEN

## KEEP OUT OF REACH OF CHILDREN
## DANGER — POISON

### STATEMENT OF PRACTICAL TREATMENT

IF SWALLOWED - Induce vomiting by giving a tablespoonful of salt in a glass of warm water. Repeat until vomitus is clear. Call a physician immediately.

IF INHALED - Remove to fresh air. Call a physician immediately.

IF IN EYES - Flush eyes with plenty of water for at least 15 minutes. Call a physician immediately.

IF ON SKIN - In case of contact, remove contaminated clothing and immediately wash skin with soap and water.

SEE SIDE PANEL FOR ADDITIONAL PRECAUTIONARY STATEMENTS

MFG BY A-Z CHEMICALS
TOWN, STATE

EPA EST. NO. 00475
EPA REGISTRATION NO. 1357-42

NET CONTENTS ONE GALLON

## DIRECTIONS FOR USE CONTINUED

ALFALFA: Alfalfa Weevil Larvae, Egyptian Alfalfa Weevil Larvae, Pea Aphid, and in New York state for Snout Beetle control. Apply the amount of De Pesto indicated in the chart, when feeding is noticed or when insects appear. Alfalfa Weevil Adult - Apply 1-2 pints per acre when insects appear. Lygus Bugs - Apply 2 pints per acre prior to bloom. Observe the indicated number of days after application before cutting or grazing. Do not apply more than once per season. Apply only to fields planted to pure stands of Alfalfa.

| Pints of De Pesto Per Acre | Do Not Cut or Graze Within |
|---|---|
| ½ | 7 days |
| 1 | 14 days |
| 2 | 28 days |

RED CLOVER: asdf ?lkj asdf ?lkj asdf ?lkj

The signal word "WARNING" is required on all products that are moderately toxic as the term is defined by EPA regulations.

The signal word "CAUTION" is required on all products of low order toxicity. Toxicity is reflected by the signal word on the label. Remember the signal word meanings:

DANGER means HIGHLY TOXIC
WARNING means MODERATELY TOXIC
CAUTION means LOW ORDER OF TOXICITY

The words "Keep out of reach of children" are required on all products. A statement of practical treatment must appear on the label of all products requiring signal word labeling. The label is a prime source of instructions for first aid treatment for poisoning.

PRECAUTIONARY STATEMENTS

DANGER

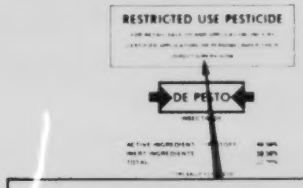
HAZARDS TO HUMANS
(& DOMESTIC ANIMALS)

Poisonous by swallowing or inhalation. Do not breathe spray mist. Do not get in eyes. Avoid contact with skin. Wear a mask or respirator of a type passed by the U. S. Bureau of Mines for De Pesto protection. For emergency assistance call 000-000-0000
TO PHYSICIAN: De Pesto is a reversible cholinesterase inhibitor. Do not use oximes such as 2-PAM. Give Atropine 2mg. intravenously or subcutaneously. If in eye instill one drop of Homatrophine.

Precautionary statements cover hazards to humans and domestic animals, environmental hazards and physical or chemical hazards. These statements describe how the product may be poisonous to man and animals and any special care necessary to avoid poisoning, such as the kind of protective equipment needed.

Environmental hazard information includes special precautions for using a product to minimize undesirable effects on the environment, for example, some products are labeled "This product is highly toxic to bees." Another typical environmental hazard caution calls attention to the special sensitivities of fish and wildlife.

The physical and chemical hazard statement lists any special fire, explosion or chemical hazards associated with the product.




RESTRICTED USE PESTICIDE

FOR RETAIL SALE TO AND APPLICATION ONLY BY CERTIFIED APPLICATORS OR PERSONS UNDER THEIR DIRECT SUPERVISION

Every pesticide label must show whether the contents are for general or restricted use. A restricted-use pesticide is one which could cause injury to the applicator or unreasonable adverse effects on the environment. The label on these products will read "Restricted-use pesticide for retail sale to and application only by certified applicators or persons under their direct supervision." The label of products other than restricted use carries the words "General Classification."

DIRECTIONS FOR
RESTRICTED USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

RE ENTRY STATEMENT

The information essential for proper use of the product appears as directions regarding:

- The crop, animal or site to which the product is to be applied
- The specific pest or pests controlled by the product

. The situation, location and conditions under which the product should be used

. Rate and equipment requirements

. How to apply the product

. When to apply the product

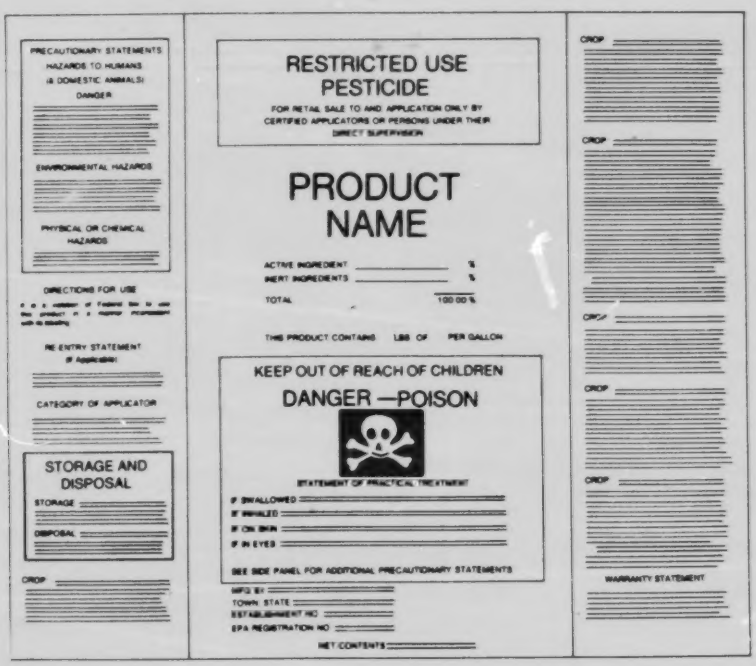
This section of the pesticide label also includes limitations, such as those relating to reentry.

Federal regulations establish reentry times to be observed with certain pesticides and establish certain procedures for warning workers before treating fields. These reentry times are to be observed unless the label specifies a longer interval between application and reentry in which case the label restriction is to be observed.

Another common limitation statement is the number of days between application and harvest or other uses such as grazing. In the case of livestock and poultry, the limitation may specify the time between the last application of a pesticide and marketing for slaughter or possibly a limitation with regard to marketing milk.

Storage and disposal instructions are required as part of the label. The rinse and drain procedure will reduce the amount of the product remaining in the container.

Part or all of the pesticide label may be written in other languages; the same label requirements apply regardless of language.



The label includes product identity information, directions for use and various precautionary statements, all of which are essential for proper and safe use. Remember the prime source of information about a pesticide product and its use is the label.

## REVIEW QUESTIONS

### LABELS AND LABELING

1. The pesticide label must include

   a) an EPA lot number
   b) an EPA registration number
   c) an EPA establishment number

2. Match the signal word with the appropriate product toxicity

   a) _____ Danger — 1. Moderately toxic
   b) _____ Warning — 2. Low order toxicity
   c) _____ Caution — 3. Highly toxic

3. In addition to the appropriate signal word, the highly toxic pesticide product label must include

   a) the acute oral $LD_{50}$
   b) the $LC_{50}$
   c) a section informing physicians of the proper treatment for poisoning

4. The words "Keep Out of Reach of Children" must appear on labels of

   a) pesticide products which are highly toxic
   b) all pesticide products
   c) insecticide products only

5. The preharvest interval identifies the

   a) time to be observed between treatment of a field and reentry by unprotected workers
   b) time a pesticide is to be used
   c) number of days between the last application of a pesticide and harvest or other use such as grazing

## PESTICIDES

Commonly used pesticides include insecticides, herbicides, fungicides, nematicides, harvest-aid chemicals, bactericides, avicides, molluscicides, and others. Pesticides are biologically active and are used to control insects, weeds, plant diseases, bacteria, snails, slugs, fish and birds and to facilitate harvesting crops. Further divisions are identified by separate terms such as acaracides, a term identifying pesticides used for mites, or rodenticides, pesticides used for rodent control. Other compounds called pesticides are used to control pests by action other than killing. These substances are more correctly called repellants and attractants.

Insecticides may be grouped for study in a number of ways. One grouping is based on how the insecticide gains entrance into the body of the insect, generally resulting in five basic categories.

- *Stomach insecticides.* Chemicals penetrate the insect through the digestive tract and kill it as the poison is absorbed through the gut. Paris green or copper acetoarsenite is a stomach poison.
- *Contact insecticides.* Chemicals kill the insect by contacting any part of the body. Lindane, pyrethrins, thiocyanates and oils are examples of contact insecticides.
- *Fumigant insecticides.* Chemicals penetrate the insect through its respiratory organs. These insecticides have the ability to volatilize (become a gas or vapor) readily. Methyl bromide, phosgene, hydrocyanic acid, aluminum phosphide, paradichlorobenzene and napthalene are fumigant insecticides.
- *Systemic insecticides.* Chemicals move through the vascular system of plants and poison insects that feed on the plants or poison internal and external parasites of animals as the chemicals move through the circulatory system. Disulfoton is a systemic insecticide used for controlling insects such as aphids, mites or scales on plants.
- *Desiccant insecticides.* These insecticides are dusts which scratch or scrape the outer layer of the exoskeleton causing the insect to lose body fluids and die from dehydration. Silicon dioxide is an example.

The majority of compounds used can enter the insect body by more than one route. For example, a compound may function not only as a stomach insecticide but as a contact insecticide as well.

Insecticides also may be classified according to the life cycle stage in which they are most effective. Ovicides are most effective against the egg stages of insects, whereas larvicides and adulticides are most effective against the larval and adult forms, respectively.

Other methods of classifying or grouping insecticides for study include chemical classification and classification by origin. Chemically, pesticides can be grouped for the most part into 29 different chemical groups. Many of the more commonly used insecticides fall into a few broad chemical categories to include organochlorines, organophosphates and carbamates.

Organochlorine insecticides, sometimes called chlorinated hydrocarbons,

include such insecticides as methoxychlor, toxaphene, strobane, benzene hexachloride, lindane, dicofol, endosulfan, mirex, chlordane, aldrin, dieldrin, heptachlor and endrin. The first synthetic organic insecticide discovered and used extensively for a number of years was DDT, the insecticidal properties of which were discovered by Dr. Paul Muller in 1939.

Some organochlorine insecticides are quite stable and may persist in the environment for extended periods. This characteristic contributes to their value as insecticides but has resulted in limitations on some uses previously permitted.

Organophosphorus compounds were discovered in the 1800's; however, it was not until the 1930's that attention was directed to the highly toxic properties of these compounds, and in 1941 the cholinesterase inhibiting action of the organophosphorus compounds was discovered. In 1944 parathion was synthesized, and its insecticidal properties were noted in 1945. This group includes among others TEPP, parathion, methyl parathion, azinphosmethyl, monocrotophos, dicrotophos, diazinon, malathion, EPN, disulfoton, phorate, trichlorfon, ethion, chlorpyrifos and methyl trithion.

Carbamates, derivatives of carbamic acid, represent another group of insecticides, many of which are commonly used to include carbaryl, carbofuran, propoxur, mexacarbate, methomyl and aldicarb. The carbamates are also cholinesterase inhibitors.

A number of inorganic chemicals are used as insecticides. Compounds of arsenic, fluorine, phosphorus and sulfur are used as insecticides. Examples are calcium arsenate, sodium fluoaluminate (cryolite), aluminum phosphide and lime sulfur.

Some insecticides are occasionally called botanicals and include pyrethrum, rotenone, Ryania, Sabadilla and nicotine. Pyrethrum, for example, is derived from the flowers of certain daisies of the genus Chrysanthemum.

Microbial insecticides also are used although relatively few in number. One of the more widely used microbial insecticides is the spores of *Bacillus thuringiensis* (Berliner) which when ingested by susceptible insects causes death from a toxin in the spores. This material is selective, killing only a few caterpillar species.

Repellents include Bordeaux mixture, dimethyl phthalate, indalone, creosote and benzyl benzoate. Attractants include compounds such as geranol, eugenol, methyl eugenol, isoamyl salicylate and medlure.

Herbicide chemicals used to kill or inhibit undesirable plant growth may be subdivided into groups according to their selectivity and mode of action. This system results in several categories. Contact herbicides kill primarily by contact with plant tissue. Only that portion of the plant contacted is directly affected and the effect usually is rapid. Complete coverage is necessary for complete control. Contact herbicides include sodium chlorate, sodium arsenite, ammonium sulfamate, cacodylic acid, monosodium methanearsonate, paraquat, diquat, herbicidal oils, etc.

Systemic or translocated herbicides are moved within the plant away from the site of application and may affect the plant by interferring with normal

processes of growth, respiration, etc. essential to plant life. Examples include dicamba, 2,4-D, 2,4,5-T, dalapon and picloram. Other herbicides may act upon the root system of plants or on germinating seeds.

Herbicide treatments are either selective or nonselective. Nonselective herbidices are sometimes called soil sterilants. Selective herbicides may be classified further as preplant, preemergent and postemergent herbicides. Preplant herbicides are applied to the soil before seeding the crop, some of which require incorporation after application. Preemergent herbicides may be applied before seeding the crop, preemergent to the crop or preemergent to both crop and weeds. Postemergent herbicides are applied following emergence of the crop or weeds or both. Selectivity of some herbicides is actually accomplished by placement rather than be chemical selectivity.

Fungicides generally consisting of three main types are chemicals which control the causes of many plant diseases.

- Protective fungicides to be applied before invasion by the disease-causing organism.
- Eradicant fungicides which control organisms already established in the host plant.
- Therapeutic fungicides to cure plant diseases.

Most fungicides function through contact involving the protection principle and complete coverage is essential. Some fungicides are systemic and are distributed throughout the plant. In addition to fungicides, chemicals classed as bactericides and nematicides are used to control bacteria and nematodes, respectively.

Bordeaux mixture and copper compounds were early fungicides still used in controlling certain plant diseases.

The class of fungicides called dithiocarbamates, includes ziram, zineb, thiram, maneb, captan, dichloran, dinocap and chloranil. Other disease-protection chemicals include antibiotics and a newer class of compounds called benzimidazole compounds such as benomyl and thiabendazole. Soil-borne diseases are controlled with soil fumigants such as chloropicrin and methyl bromide.

Harvest-aid chemicals have been developed to chemically prepare plants for mechanical harvesting. These chemicals may be classified into three categories:

- Defoliants which induce leaf abscission or leaf drop
- Desiccants which kill leaves but do not induce leaf drop
- Wiltants which kill leaf blades but not the petioles, thus allowing leaf drop.

Commercial defoliants are of two main types--chlorates and organophosphorus compounds. Available desiccants are arsenic acid and paraquat. Neodecanoic acid is used as a wiltant.

A number of different pesticide forms are called formulations. A formulation is a mixture consisting of the pesticide, called the active ingredient or technical material, and one or more other ingredients such as a carrier or diluent, emulsifiers, sticking agents, etc. The ingredients other than the pesticide may or may not be pesticidally active. An adjuvant is a nontoxic material added to the pesticide to improve its physical or chemical characteristics. Adjuvants include surface active agents (anionic, cationic and nonionic), adhesives or stickers and synergists. Common

formulations include emulsifiable concentrates, wettable powders, soluble powders, granules, dusts, baits and aerosols.

Emulsifiable concentrates consist of the pesticide and an emulsifying agent in an organic solvent. The organic solvent may be one that evaporates with the water after spraying, leaving a pesticide deposit on the plant or a nonvolatile solvent which covers the treated surface with a solution of the pesticide in oil. Emulsifying agents permit the organic product to disperse in water forming an emulsion, a milky appearing mixture when water is added. Invert emulsions differ from emulsifiable concentrates because a water solution of the pesticide is dispersed in oil forming a thick mayonnaise-like mixture.

Dusts consist of the pesticide and a carrier or diluent, usually talcs, clays, diatomaceous earth, etc. Sometime mixtures of the carriers are used to obtain the desired bulk density.

Wettable powders are similar to dust formulations except a wetting agent and sometimes a spreader-sticker are added. The wetting agent makes is possible to disperse or suspend the wettable powder in water for use as a spray.

Soluble powders are similar to wettable powders except that the particles completely dissolve in water rather than going into suspension.

Granules contain the pesticide and a carrier or diluent, such as attaclay, vermiculite or some similar inert material mechanically formed into pellets or granules. Often a binder is added to improve the stability of the pellet or granule, reducing the amount of dusts or "fines" formed upon handling.

Baits are available in various types and consist of the pesticide and a material that the pests will readily eat. Baits may contain sugar, molasses, apple pomace and similar food products.

Some chemical compounds may be adapted to all formulations while others by reason of their physical and chemical properties may be limited to only one or two. Choose the formulation that best suits the needs of the particular pest control situation.

## REVIEW QUESTIONS

### PESTICIDES

1. Pesticides include

   a) insecticides
   b) herbicides
   c) fungicides
   d) all of the above

2. An ovicide is most effective against

   a) the larval stage of insects

b) the pupal stage of insects
c) the egg stage of insects
d) adult forms of insects

3. Carbamates, derivatives of carbamic acid, used as insecticides include

a) methyl parathion
b) carbaryl
c) methoxychlor
d) lindane

4. A herbicide that is moved within the plant away from the site of application is called a

a) contact herbicide
b) systemic herbicide
c) translocated herbicide
d) soil sterilant

5. Most fungicides function

a) systemically
b) by contact
c) by sterilization

6. A mixture consisting of active ingredient(s) and one or more other ingredients such as a carrier or diluent, emulsifiers, sticking agents, etc, is commonly known as

a) a technical material
b) an adjuvant
c) a formulation

## AERIAL APPLICATION

Effective aerial application requires:
- . Close cooperation between applicator and grower when planning a job
- . Consideration of environmental effects
- . Consideration for the safety of people, animals and nontarget crops
- . Proper and well maintained equipment
- . Accurate and uniform application
- . A competent pilot
- . Staying with the planned procedure

Limitations of aerial application include:
- . Weather conditions
- . Obstructions in treating areas
- . Small or irregularly shaped areas
- . Long ferrying distances

Fixed and rotary wing aircraft are used for aerial application. Metering and dispersal equipment on the aircraft must meter quantities of pesticide mixtures accurately and deliver them uniformly.

Liquid systems

Liquid systems may be wind-driven or powered by hydraulic motors. Wind-driven systems should have a brake to stop the pump if the nozzles fail to cut off or a line breaks.

Liquid systems consist of the following parts:

- Tank
- Agitation system
- Pump
- Piping and fittings
- Screens
- Booms
- Nozzles

*Tank* - The tank should be leakproof and corrosion-resistant with a mechanism for emptying the contents quickly in case of emergency. In addition, the tank should have an accurate quantity gauge and be fitted with a tube type or spring-loaded, flapper-valve air vent.

*Agitation* - Recirculation during ferrying to the worksite and during turn-arounds usually provides required mixture agitation.

*Pump* - The pump should deliver mixtures at desired flow rates.

*Piping and fittings* - Piping and fittings should be sized to carry the maximum anticipated flow.

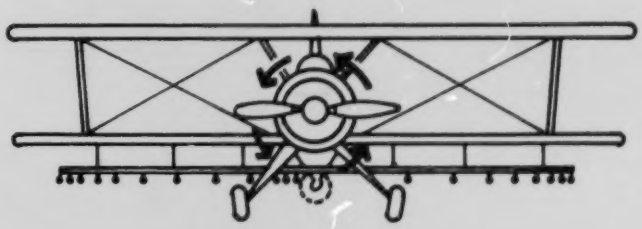
*Filters (screens)* - Locate line screen between the tank and pump or between the pump and boom. Properly sized line and nozzle screens assist in preventing nozzle clogging. Screens should be sized to match nozzle opening. Manufacturer catalogs specify screen sizes for specific nozzles.

*Boom* - The boom supports and supplies the nozzles. When the boom is located near the trailing edge of the wing, clearance between control surfaces of the wing and the boom is essential. End caps on the boom make flushing easier. The boom should be equipped with a positive shutoff valve.

*Nozzles* - Special nozzles available for aircraft systems, should be equipped with an antisiphon or no-drip check valve. Use manufacturer's specifications as a buying guide. The spray pattern shifts in the direction of propeller rotation. Adjusting the distance between nozzles helps correct this problem. Pattern checks are necessary on individual aircraft to get the best possible spacing for the most uniform pattern. A boom approximately three-fourths as long as the wing span allows placing end nozzles inboard to prevent the wingtip vortex from trapping fine droplets and causing uneven distribution and drift. The end nozzle should be at least three feet from the wingtip.

Adjustment of nozzle spacing is especially important when spraying less than ten feet in height. For applications above ten feet nozzles may be spaced uniformly along the boom.

Nozzle placement on a helicopter boom may be uniform except where the spray hits parts of the aircraft such as the skids. A rear section boom is sometimes used to keep spray off the helicopter.



Front view of variable distance nozzle placement

## ULV systems

Ultra low volume (ULV) spraying requires a special liquid dispersal system. Manufacturers can supply specifications for ULV systems. Few pesticides are labeled for ULV aerial application.

## Dry systems

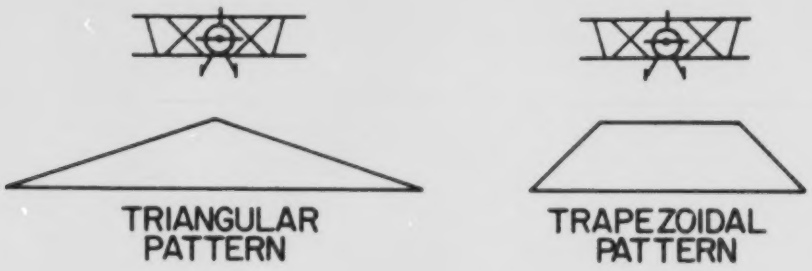
The application equipment and the size, shape, density and flowability of materials affect swathwidth and pattern when applying dry formulations. The hopper must have steep walls to insure uninterrupted flow and a lid that closes tightly. An agitator keeps fine materials from bridging. The air vent may be a spring-loaded flapper valve or tube type. An adjustable gate is necessary to regulate flow rate and must have a tight seal when closed. Check the gate often to be sure it is set properly and not leaking.

## Calibration

Calibration is adjusting equipment to apply the desired pesticide rate. Calibration is especially important in aerial application, as large areas are covered in a short time. Calibrate often to assure correct adjustment.

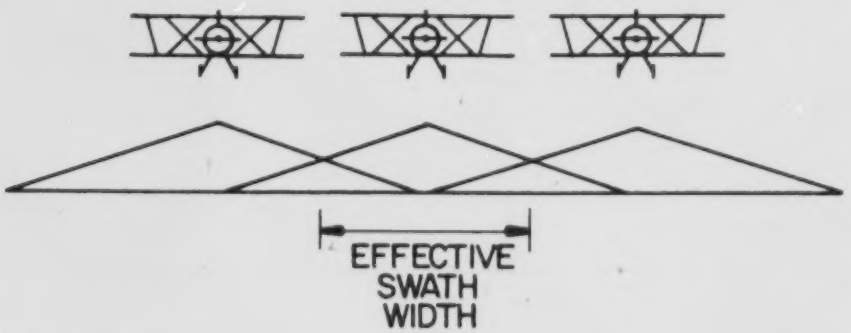
*Pattern testing* - Pattern testing is the first step in calibration. The pattern is checked to assure uniform distribution across the swath. Helicopters and fixed-wing aircraft create wind currents (vortices) that affect swath pattern. The pattern is also checked to determine effective swathwidth. Tests must duplicate the airspeed, altitude, spray pressure and nozzle angle and placement or gate settings that will be used for the actual applications. Make pattern tests with winds less than three mph to avoid distortion from crosswinds.
To test a liquid pattern, add a dye or fluorescent tracer material to the water in the tank of the aircraft. For dry pattern testing, use a blank material with properties similar to the formulation to be applied if possible. Collect the test material on paper for liquids or in buckets for dry materials placed across the flight path on the ground. Observation of the collected materials shows the actual swath pattern.

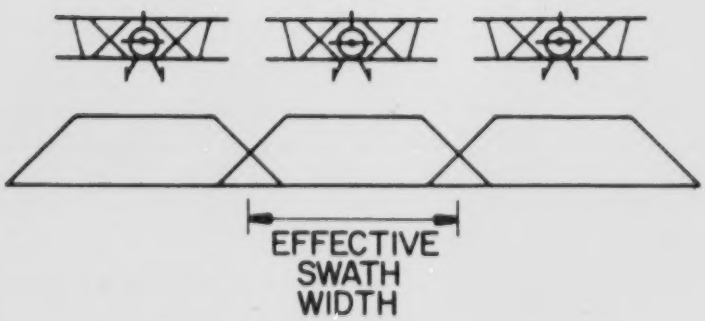
An ideal distribution pattern approximates either a triangular or trapezoidal pattern with the maximum application rate centered under the aircraft's flight path. The application rate tapers off at the edges of the pattern.




If the pattern is triangular shaped, the most uniform field application should occur when the edge of one swath corresponds to the centerline of the adjacent swath. If the pattern is trapezoidal in shape, the most uniform field application should occur when the tapered portions are half-lapped.

For either shape, the effective swathwidth is the distance between the points on the tapered-edge portions of the distribution pattern where the application rate equals one-half of the maximum rate for the pattern.



*Liquid calibration* - Steps in sprayer calibration are as follows:

- Determine the acres the aircraft system will treat per minute at the planned flying speed and height.
- Calculate the gallons that must be sprayed per minute to apply the chemical mixture within the recommended spray volume range.
- Select the size and number of nozzle tips at a selected system operating pressure that delivers the required gallons per minute.
- Make a trial run to determine the actual gallons per acre applied.
- Determine the amount of pesticide to add to the tank.

The basic formula for calibrating or determining gallons-per-acre rate is to divide the gallons sprayed per minute by the acres covered per minute.

$$\text{Gallons per acre} = \frac{\text{gallons per minute}}{\text{acres per minute}}$$

The following example explains the calibration steps. An aircraft has a 300-gallon tank with an effective swathwidth of 50 feet. The application flying speed is 100 miles per hour. The operating pressure will be 40 pounds per square inch and the boom will have 26 nozzles. The chemical label calls for applying one pint of chemical in a 2½ - 3-gallon solution per acre.

The acres covered per minute are determined by this formula.

$$\text{Acres per minute} = \frac{2 \times \text{swathwidth} \times \text{speed}}{1000}$$

Using a swathwidth of 50 feet and a speed of 100 miles per hour in the formula, the acres per minute are 10.

$$\text{Acres per minute} = \frac{2 \times 50 \times 100}{1000} = 10$$

The following table shows the acres covered per minute when the swathwidth and aircraft speed are known.

ACRES PER MINUTE FOR VARIOUS SPEEDS AND SWATHWIDTHS

| Speed | Swathwidth | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (mph) | 30 | 35 | 40 | 45 | 50 | 75 | 100 | 200 |
| 40 | 2.4 | 2.8 | 3.2 | 3.6 | 4.0 | 6.0 | 8.0 | 16.0 |
| 50 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 7.5 | 10.0 | 20.0 |
| 60 | 3.6 | 4.2 | 4.8 | 5.4 | 6.0 | 9.0 | 12.0 | 24.0 |
| 70 | 4.2 | 4.9 | 5.6 | 6.3 | 7.0 | 10.5 | 14.0 | 28.0 |
| 80 | 4.8 | 5.6 | 6.4 | 7.2 | 8.0 | 12.0 | 16.0 | 32.0 |
| 90 | 5.4 | 6.3 | 7.2 | 8.1 | 9.0 | 13.5 | 18.0 | 36.0 |
| 100 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 15.0 | 20.0 | 40.0 |
| 110 | 6.6 | 7.7 | 8.8 | 9.9 | 11.0 | 16.5 | 22.0 | 44.0 |
| 120 | 7.2 | 8.4 | 9.6 | 10.8 | 12.0 | 18.0 | 24.0 | 48.0 |

To determine the gallons per minute required, multiply the acres per minute times the required gallons of solution per acre.

$$\text{Gallons per minute} = \text{acres per minute} \times \text{gallons per acre}$$

The acres per minute covered by the aircraft are 10. Since the chemical label gives a range of 2½ to 3 gallons of solution per acre, the 3 gallon-per-acre rate was selected. Substituting in the formula, the result is a required rate of 30 gallons per minute. At this point, be sure the pump will deliver the required gallons per minute rate.

$$\text{Gallons per minute} = \text{acres per minute} \times \text{gallons per acre}$$
$$\text{Gallons per minute} = 10 \times 3 = 30$$

Determine the gallons per minute per nozzle by this formula.

$$\text{Gallons per minute/nozzle} = \frac{\text{gallons per minute}}{\text{number of nozzles}}$$

The total gallons per minute required has been determined to be 30. If 30 is divided by the number of nozzles on the boom, which is 26, a required nozzle delivery of 1.16 gallons per minute is obtained.

$$\text{Gallons per minute/nozzle} = \frac{\text{gallons per minute}}{\text{number of nozzles}}$$

$$\text{Gallons per minute/nozzle} = \frac{30}{26} = 1.16$$

Using a manufacturer's catalog with the selected operating pressure of 40 pounds per square inch, select a nozzle that delivers 1.16 gallons per minute. The nozzle nearest to the needs may deliver only 1.10 gallons per minute. This small difference may be adjusted by increasing pressure or by applying less than 3 gallons per acre as long as it is in the range of 2½ to 3 gallons per acre specified by the label.

As the next step, make a trial run to get the actual gallons-per-acre rate applied. Fill the tank with water to a known level on a level apron or strip. Fly the aircraft at the 100 miles per hour and spray at the selected pressure for a timed period. This period should be sufficient to allow an accurate measurement of the amount of water sprayed.

Bring the aircraft back to the same point and measure the amount of water needed to refill the tank to the original mark, dividing by the number of minutes sprayed to determine the gallons per minute sprayed.

$$\text{Gallons per minute} = \frac{\text{gallons sprayed}}{\text{number of minutes sprayed}}$$

For a trial run example, 29 gallons of water were sprayed in a timed period of one minute, giving a 29 gallons-per-minute spray rate.

$$\text{Gallons per minute} = \frac{\text{gallons sprayed}}{\text{number of minutes sprayed}}$$

$$\text{Gallons per minute} = \frac{29}{1} = 29$$

Going back to the calibration formula, if the 29 gallons per minute are divided by the 10 acres covered per minute, a rate of 2.9 gallons per acre results.

$$\text{Gallons/acre} = \frac{\text{gallons/minute}}{\text{acres/minute}}$$

$$\text{Gallons/acre} = \frac{29}{10} = 2.9$$

Since this rate is within the chemical label range of 2½ to 3 gallons per acre, this application rate may be chosen.

Determine the amount of chemical to add to the tank. This may be done by multiplying the acres a tank will cover by the amount of chemical to be applied per acre.

$$\text{Chemical/tank} = \text{acre/tank} \times \text{chemical/acre}$$

To find the acres a tank will cover, divide the gallons in the tank by the gallons-per-acre rate.

$$\text{Acres/tank} = \frac{\text{gallons/tank}}{\text{gallons/acre}}$$

If the 300-gallon tank is filled to 290 gallons and 2.9 gallons per acre are applied, the acres per tank will be 100.

$$\text{Acres/tank} = \frac{\text{gallons/tank}}{\text{gallons/acre}}$$

$$\text{Acres/tank} = \frac{290}{2.9} = 100$$

The application rate is one pint per acre, so the chemical per 290-gallon tank would be 100 pints or 12½ gallons.

$$\text{Chemical/tank} = \text{acre/tank} \times \text{chemical/acre}$$
$$\text{Chemical/tank} = 100 \times 1 = 100 \text{ pints}$$

Then make a trial run with the mixture to check the *actual* application rate.

*Dry calibration* - A dry material applicator may be calibrated in a manner similar to that of calibrating a sprayer. Make several test flights with the spreader installed to determine the quantity of material metered out for a given rate setting. Helicopters may use electric or hydraulic air blowers and the material can be caught and measured while running up on the ground. If available, use inert or blank granules of the same size and density as those in the formulation to be applied. Operate the spreader for a measured period of at least 30 seconds. Weigh the quantity needed to refill the hopper.

Pounds of dry material spread per acre may be found by dividing the pounds spread per minute by the acres covered per minute.

$$\text{Pounds/acre} = \frac{\text{pounds/minute}}{\text{acres/minute}}$$

The acres covered per minute are determined in the same manner as with a sprayer, knowing flying speed and swathwidth.

To calculate the required pounds of material to be spread per minute for a given amount of material spread per acre, multiply the pounds per acre by the acres covered per minute. It may take several trial gate settings to determine which one gives the required discharge in pounds per minute of granular material.

$$\text{Pounds/minute} = \text{pounds/acre} \times \text{acre/minute}$$

Checking calibration

After a liquid or dry material system has been initially calibrated, the operator may want to use an area method of checking calibration on individual jobs. The area method of calibration determines the amount of material applied to a given area.

The basic formula for the liquid system area method of determining gallons per acre rate is to divide the gallons applied over a given area by the acres in the given area.

$$\text{Gallons per acre} = \frac{\text{gallons applied}}{\text{acres covered}}$$

Operate the system over a measured distance and measure the number of gallons applied. The acres covered would be the measured distance in feet multiplied by the swathwidth in feet and divided by 43,560.

The formula for the dry system area method of determining the pounds per acre rate is to divide the pounds applied over a given area by the acres in the given area.

$$\text{Pounds per acre} = \frac{\text{pounds applied}}{\text{acres covered}}$$

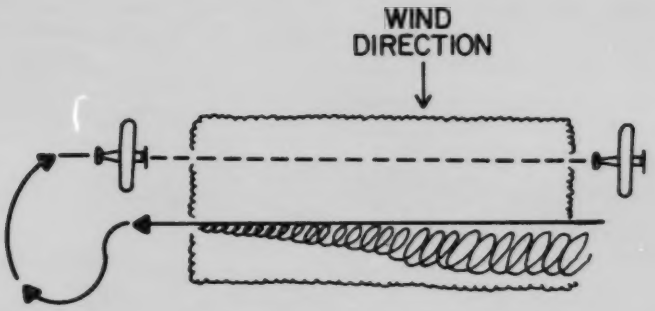
Operate the dry system over a measured distance and measure the number of pounds applied. The acres covered would be the measured distance in feet multiplied by the swath width in feet and divided by 43,560.

When an aircraft has been calibrated, the airspeed, spraying pressure or gate setting for dry materials, height of flight and effective swathwidth are fixed. Applications must be made at the same settings.

Operation

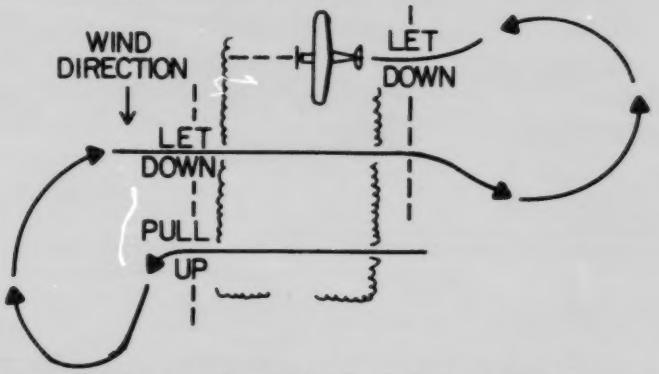
*Pressure* - Pressure should not exceed 40 to 50 pounds per square inch. Choose the pressure near this range that combines the selected swathwidth, airspeed and nozzle type to give the proper application rate. With most nozzle types, droplet size decreases as pump pressure increases. Use pressure gauges to indicate boom or pump pressure.

*Field flight patterns* - For rectangular fields, fly back and forth across the field in parallel lines. Flying parallel to the long axis of the field reduces the number of turns. For pilot safety, start treatment on the downwind side of the field to prevent flying through the previous swath. To prevent skips and drift, stop flying if windspeed increases excessively.




If the area is too rugged or steep for this pattern, flight lines should follow the contours of the slopes. When the area is too steep for contour work, make all applications downslope.

*Turnaround* - At the end of each swath, the pilot should shut off the dispersal equipment and pull up out of the field before beginning his turn. Complete the turn in time to permit slight course corrections before dropping into the field again for the next swath.




*Swath marking* - Swaths can be marked with permanent or semipermanent flags set above the height of the crop to guide the pilot. This method is useful if the field will be treated several times in a season.

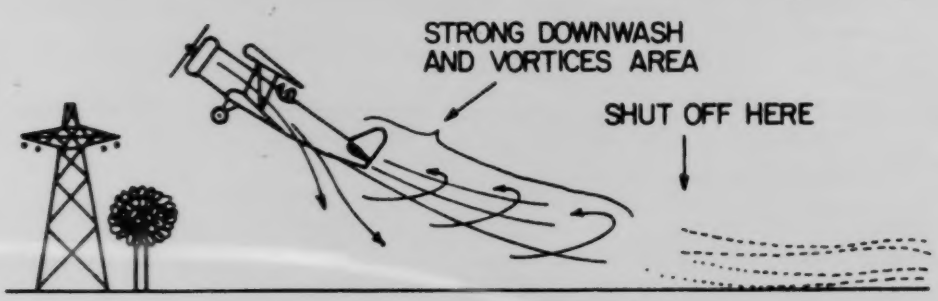
Two flagmen can help the pilot line up on the field. With this accomplished, the nearer flagman starts pacing off or counting crop rows to the next swath. Flagmen should avoid being sprayed and should never turn their backs toward an oncoming aircraft. When the aircraft is being flown parallel to a row crop, one flagman can identify the swath row for the pilot.

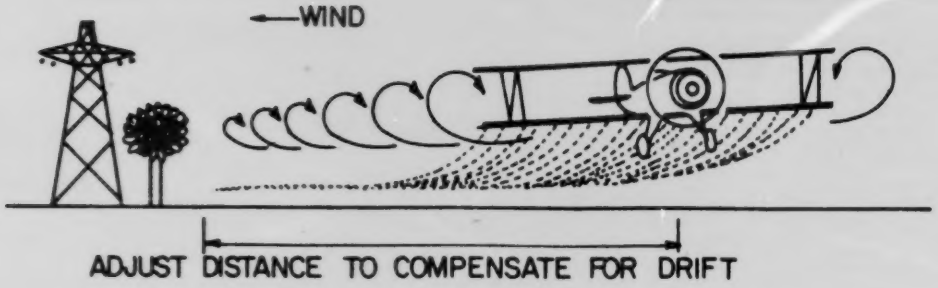
Automatic flagmen are often used. These devices, attached to the aircraft and controlled by the pilot, release weighted streamers. The streamers give the pilot a visible mark to help him judge the next swath.

On small field applications, helicopters may not need flagmen. Their short turnarounds allow them to locate the next swath easily.

*Obstructions* - If there are obstructions -- trees, power and telephone lines or buildings -- outside the field at the beginning or end of the swath, turn the equipment on late or shut off early. When the field is completed, fly one

or two swaths crosswise or parallel to the obstruction to complete the job. Treat obstructions inside the field in the same way. Skip the area around the obstruction and spot treat later.





Treat areas next to buildings, residences, livestock, nontarget crops or waterways with caution; observing the following points:

- Fly parallel to the sensitive area.
- Leave a border of untreated crop to avoid possible drift onto the area
- Avoid making turns over dwellings where possible.
- Remind the customer to warn beekeepers at least one day before application if beehives are located near treatment area.

*Controlling drift* - Drift is the airborne movement of spray, granule or dust particles to places other than the target area. Properly controlled drift may help the pesticide reach the target. Drift is harmful when it causes damage in nontarget areas.

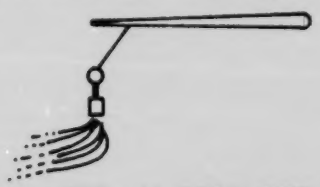
Droplet size is one of the most important factors affecting drift. Small droplets are a much greater drift hazard than large droplets. They stay in the air longer and are more easily carried by wind currents. Pesticide sprayer systems cannot produce a completely uniform droplet size; rather, they produce a range of droplet sizes.

Nozzle type and pressure are important factors affecting droplet size. Generally, the size of droplets decreases as the size of the nozzle opening decreases or the pressure increases.

Nozzle position on the boom affects droplet size. Aiming the nozzle orifice straight back produces the coarsest droplets.

COARSE DROPLETS

The straight down nozzle produces smaller droplets.



MEDIUM DROPLETS

Aiming the nozzle downward and forward at a 45° angle produces the finest droplets.

FINE DROPLETS

Don't aim the orifice forward and downward at less than 45° from the horizontal. This causes spray collection on the structure.

NOT THIS

Flight speed and available chemical adjuvants affect droplet size. Thickening agents may be added to spray mixtures to create larger spray particles. Surfactants are sometimes added to spray solutions to create smaller droplets, improve coverage and increase a spray's wettability. Be sure that droplets are large enough to avoid a drift problem.

Weather conditions directly affect the direction, amount and distance of drift. Avoid applications when the wind is blowing toward susceptible crops.

A pesticide applicator is concerned mainly with weather in the immediate area of application and less than 1,000 feet off the ground. The weather in this small area has a major effect on the pesticide application, including the chance for drift problems. Wind is an important weather factor affecting drift. Stop at once if wind increases excessively during application.

"Inversion" and "lapse" are other important factors referring to temperature change from the ground upward. An inversion layer exists in still air that:

- Is coolest at the ground level
- Gets warmer up to a certain height
- Gets cooler from that point upward

Particles released into the cool air layer at ground level during an inversion have a minimum upward movement. The slightest air movement causes this mass of particles to drift for great distances before falling.

A lapse exists when the air:

- Is warmest at ground level
- Gets continuously cooler at high elevations

During strong lapse, the warm air near the ground rises, carrying very small pesticide particles with it. An applicator should be aware of these two conditions, because sometimes they can cause serious drift problems.

*Vaporization* or vapor drift is another type of pesticide movement. This is the volatilization of an active ingredient during or after application. High temperatures and other climatic conditions cause vaporization. Apply highly volatile materials during periods of relatively low temperature and high humidity. Use active ingredients with low volatility where vaporization might cause problems.

*Protecting bees* - Honey bees and other beneficial insects can be harmed by some pesticide applications. Beekeepers, aerial applicators and their customers must cooperate closely to protect honey bees. Bee losses can be reduced significantly by careful planning and good communications. Bees travel long distances, so use of pesticides toxic to bees may affect hives outside the immediate vicinity of the treatment area. When using materials hazardous to bees, remind customers

to notify the beekeeper at least one day before application. With few exceptions, dusts may be more hazardous to bees than sprays. Treatment during the night and early morning before bees are foraging are the safest times for bees.

Safety precautions

*General precautions* to follow include:
. Wearing protective clothing and equipment appropriate for the pesticide.
. The label on each pesticide specifies the required protection.
. Being familiar with the pesticide being applied and how to get emergency help if needed.
. Avoiding all unnecessary contact with spray or dust.
. Changing clothing and bathing after each day's work.

*The pilot* should follow these precautions:
. Avoid loading or handling highly hazardous pesticides. Exposure to toxic pesticides can cause illness making it unsafe to operate the aircraft.
. Make preflight aircraft check.
. Check operation and calibration of dispersal equipment periodically.
. Check target area and surroundings for safety or drift hazards before application.
. Avoid flying through drift.
. Do not apply pesticides over flagmen or other persons.
. See that members of the ground crew know their responsibilities and are acquainted with label precautions.
. Do not fly in a manner or at a time which may create a hazard even if customer insists.
. Inform all people in treatment area about the application.

*Ground crew* personnel should be concerned with the following precautions:
. Close tanks and hoppers tightly after filling.
. Remove any spilled chemical.
. Clean aircraft, especially the cockpit, frequently.
. Where possible, clean equipment on a hard-surfaced apron so that runoff can be collected and disposed of safely.
. Do not stand in runoff water without appropriate protection or allow it to splash on the body.

The following precautions should be followed by *flagmen*.
. Inform all people in the treatment area about the application.
. When the aircraft is lined up for a pass, move over to the next position.
. Do not turn back on an approaching aircraft.
. Stay at the field until the pilot has completed the job in the event an accident occurs.

## REVIEW QUESTIONS

## AERIAL APPLICATION

Questions 1-5 are problems on aerial sprayer calibration.

An aircraft has a 300 gallon tank with an effective swathwidth of 40 feet. The application flying speed is 100 miles per hour. The operating pressure will be 40 pounds per square inch and the boom will have 20 nozzles. The

chemical label calls for applying 1 quart of chemical in a 4 to 5 gallon solution per acre.

Calibration formulas:

$$\text{Acres per minute} = \frac{2 \times \text{swathwidth} \times \text{speed}}{1000}$$

$$\text{Gallons per minute} = \text{acres per minute} \times \text{gallons per acre}$$

$$\text{Gallons per minute/nozzle} = \frac{\text{gallons per minute}}{\text{number of nozzles}}$$

$$\text{Gallons per minute} = \frac{\text{gallons sprayed}}{\text{number of minutes sprayed}}$$

$$\text{Chemical/tank} = \text{acres/tank} \times \text{chemical/acre}$$

$$\text{Acres/tank} = \frac{\text{gallons/tank}}{\text{gallons/acre}}$$

1. How many acres per minute will the aircraft cover?

   a) 8 b) 10 c) 6 d) 12

2. How many gallons per minute will be applied at a 5 gallon per acre solution rate?

   a) 30 b) 40 c) 50 d) 60

3. How many gallons per minute should each nozzle deliver?

   a) 1 b) 2 c) 3 d) 4

4. How many acres will a tank cover at a rate of 5 gallons of solution per acre?

   a) 20 b) 40 c) 60 d) 80

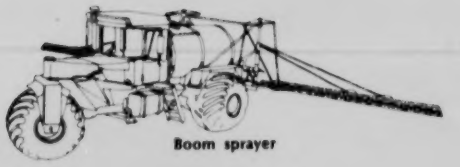
5. How much chemical would be added to each tank?

   a) 60 qts. b) 130 qts. c) 140 qts. d) 200 qts.

## GROUND APPLICATION

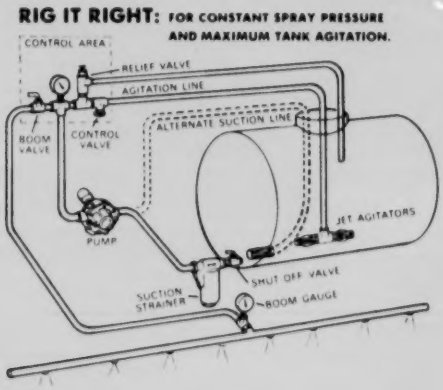
A common type of pesticide application equipment is the sprayer. Sprayers may range from a hand sprayer for garden and ornamental application, to an air sprayer for orchard application, to a boom field sprayer or to a livestock sprayer.

Hand sprayer



Boom sprayer

A sprayer has several parts. The sprayer's delivery system may be a boom with several nozzles. The strainer system consists of a screen between the tank and pump, an in-line strainer between the pump and delivery system and a screen in each nozzle. Other parts are a shutoff valve, pressure regulator and pressure gauge. The sprayer also has a bypass line, suction line, pump and tank. An agitator line with a jet agitator prevents chemicals from settling out of the liquid mixture. A mechanical paddle agitator is used in some commercially manufactured sprayers.




Pumps

The pump for agricultural sprayers should be capable of delivering the recommended discharge and pressure. No one pump is ideal for all sprayers; each type is designed for a specific application. Sprayers usually have roller, centrifugal or piston pumps.

The roller pump develops pressures up to 300 pounds per square inch with pumping capacities up to 30 gallons per minute. Nylon rollers are recommended for nonabrasive materials with rubber rollers recommended for abrasive materials such as wettable powders.

Centrifugal pumps have a high volume capacity of up to 125 gallons per minute but their low pressure limits them to applications of 50 pounds per square inch or less. Centrifugal pumps effectively handle abrasive materials such as wettable powders

Piston pumps are high pressure units operating up to 600 pounds per square inch at volumes up to 25 gallons per minute. They are very wear resistant.

Pump size is important. The pump should have capacity to supply all nozzles on the spray boom plus capacity for agitation if the sprayer tank is not outfitted with a mechanical agitator. This agitation is extremely important when using wettable powders. Agitating wettable powders requires 2 to 3 gallons per minute of pump output per 50 gallons of mixture in the tank.

Pressure gauge

Select the pressure gauge to read in the range of pressures to be used. Generally, select a gauge that has a range twice the maximum reading expected. For example, for pressures up to 50 pounds per square inch, select a 100-pound-per-square-inch gauge.

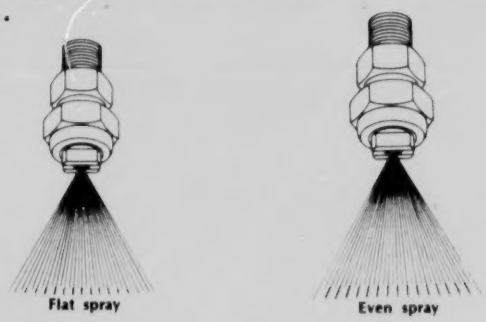
Nozzles

Nozzles control the amount of material applied, droplet size and pattern. Manufacturer catalogs contain information for choosing a nozzle to give the desired spray pattern, angle, droplet size and discharge rate. Remember that output changes as the nozzle wears and frequent checking is required for continued accurate application.

A typical nozzle includes a nozzle body, strainer, tip and cap. The nozzle strainer is selected according to manufacturer recommendations to fit the nozzle tip used. The smallest strainer recommended for spraying wettable powders is 50 mesh.

Nozzle tips are available in various materials including brass, nylon or plastic, stainless steel and hardened stainless steel. Brass tips wear extremely fast when spraying wettable powders.

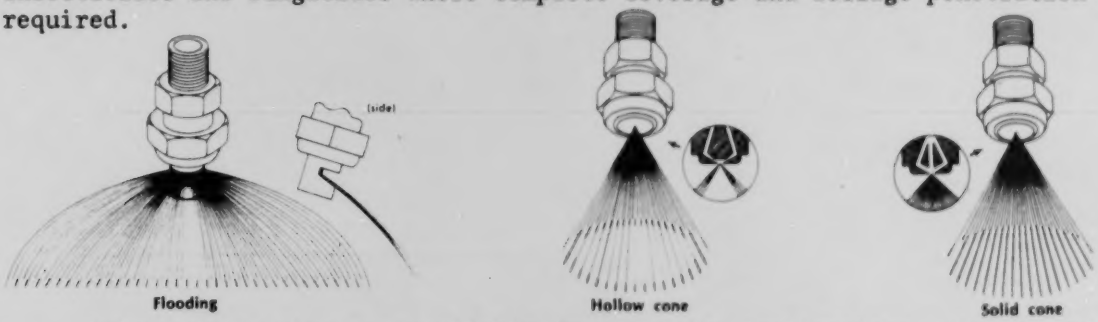
Many spray patterns are available. The flat spray tip is designed for normal operating pressures of 20 to 40 pounds per square inch. The flat spray tip produces a fan pattern with less material applied along the edges to allow overlap along a boom. With flat spray tips, the boom height is adjusted so patterns overlap on each side. The overlap is about 40 percent of the spacing between nozzles. For example, if boom nozzles are 20 inches apart, the patterns should overlap 8 inches.




Even spray tips are designed for normal operating pressures of 20 to 40 pounds per square inch. The even spray tip produces a uniform volume of spray across the entire fan width. This tip is used for band spraying.

Solid and hollow cone tips are designed for pressures of 40 to 400 pounds per square inch. This high pressure breaks the spray into small droplets for

more complete plant coverage. Cone nozzles produce a circular pattern. The hollow cone tip sprays material only along the outside of the pattern while the solid cone sprays material throughout the pattern. The type of cone selected depends on volume of spray to be applied. Cone nozzles are used for insecticides and fungicides where complete coverage and foliage penetration are required.

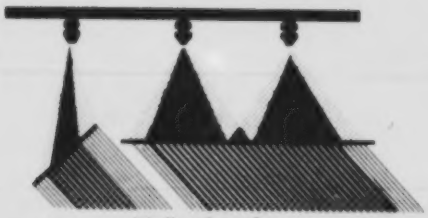



Other nozzle tips are available for specific applications. For example, a flooding nozzle sprays a wide surface while operating close to the sprayed surface. Placed at a 40-inch spacing and operated at 10 to 20 pounds per square inch, the flooding nozzle applies postemergence chemicals to the row middles of growing crops.

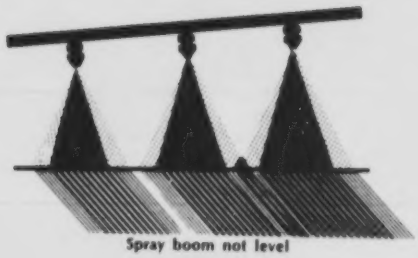
## Use and maintenance

Various problems may be encountered with boom sprayers. On a boom, be sure that all tips produce the same pattern angle. Different pattern angles can cause skips or too much overlap.

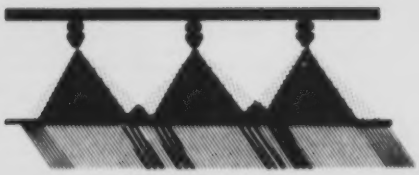
- A mixture of nozzle types gives incorrect coverage.
- Worn or plugged tips may cause skips.
- If tips are not aligned parallel with the boom, skips occur.
- If the sprayer boom is not level, coverage is irregular.
- If the pressure is too high, droplets become too small and drift, giving uneven application.
- If the pressure is too low, patterns do not overlap properly, giving inadequate coverage.



Misaligned nozzles



Spray boom not level



Spray boom too low

To clean nozzle tips, use a soft brush such as a toothbrush. Tips may be damaged if cleaned with a knife or wire.

Drift

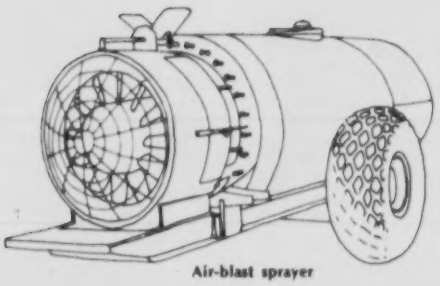
Weather conditions directly affect the direction, amount and distance of drift. Avoid applications when the wind is blowing toward susceptible crops. High winds can move pesticides from the treated area causing poor coverage and possible damage in adjoining fields.

During early morning and late evening hours, the difference in air temperature at ground level and at some distance above ground is considerably less than during the middle of the day. As the ground warms up, the air temperature near the ground increases above that of the air above the ground. This warmed air rises and may set up convection and thermal air currents which lift small particles. These suspended particles may be carried some distance before they settle out. Avoid applications when this condition exists.

Calm conditions with a high inversion of ground air 2° to 5° cooler than the air above may result in small spray droplets or dust particles remaining suspended as a dense cloud in a layer of undisturbed air. The entire cloud may move out of the area before coming to rest, resulting in relatively high drift deposits. Avoid applications under this condition. Sufficient turbulence is needed in the atmosphere to disperse clouds of small spray drops.

Air sprayers

The difference between air or mist sprayers and field or pasture sprayers is that a high volume fan is used to produce an air stream to carry spray droplets to the target area. Good coverage is very difficult in winds of more than 5 miles per hour. Air sprayers are equipped with cone nozzles to give small droplet sizes for complete coverage and are used primarily for disease

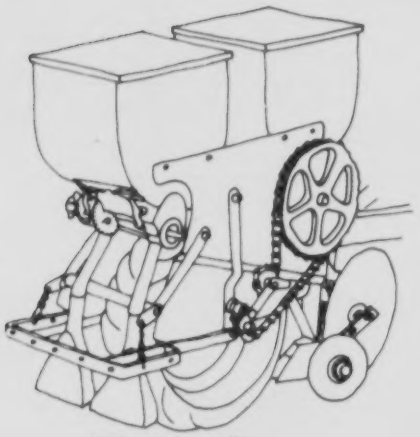


Air-blast sprayer

and insect control. Most air sprayers require high pressure and are equipped with piston or multistage centrifugal pumps.

Granular applicators

Granular applicators are available for band or broadcast coverage and may also be used for applying granular materials into the soil. Granular applicators may be operated as separate units but are often used as attachments on other equipment.



Band granular applicator

Injector equipment

Injector equipment applies liquid pesticide into the soil with the amount of pesticide applied controlled by a flow meter. This equipment is quite variable in appearance and use.

Calibration

Too often one essential operation gets overlooked in pesticide application. Calibration or equipment adjustment is essential to obtain desired rates. Calibrate application equipment before every use to insure good pest control and avoid the hazard and expense of over application.

The application rate per acre for pesticides usually is given as a broadcast rate. Rate per acre on a broadcast basis means the amount of pesticide per acre treated. With broadcast application, the entire area is covered and the rate per acre on a broadcast basis will be the same as rate per acre of land. With band application, the rate per acre on a broadcast basis is not the same as rate per acre of land. Rather, it is the rate per acre of land actually treated. For example, a herbicide rate is given as 1 pound per acre on broadcast basis. If the herbicide is broadcast, 1 pound of herbicide is applied to 1 acre of cropland. If the herbicide is applied in 12-inch bands on 36-inch rows, 1 pound of herbicide covers 3 acres of cropland.

Before calibrating a sprayer check the discharge from each nozzle. Only *water* should be used in the tank when checking nozzle discharge or calibrating a sprayer. Even though water is used, observe all pesticide safety precautions because residual pesticide may be present in the sprayer system. With the sprayer stationary and operating at the pressure to be used in the field, catch and record the spray discharge in ounces from each nozzle. Calculate the average nozzle discharge per minute by adding the discharge from each nozzle and dividing by the number of nozzles. Replace the tip in any nozzle that has a flow rate of 10 percent more or less than the average of the nozzles in the system. If any nozzle tips are replaced, catch the discharge for 1 minute, calculate a new average and check to see if the new tips fit within the discharge limits.

Many methods of sprayer calibration may be used. It is important that some calibration method be used so that equipment may be adjusted to apply the desired amount of a pesticide to a given area.

Some operators prefer to calibrate by spraying an *exact* known area such as an acre, a half acre or a quarter acre. This is a good method that requires minimum calculation to determine gallons of mixture applied per acre.

Two calibration methods - a known area method and a stationary method - are discussed in the following material.

Known area method

- Measure a distance in the field to be sprayed. A good distance is 660 feet.
- Fill the sprayer tank with water to a known level.
- Select a tractor throttle or miles-per-hour setting in the gear to be used.
- Select a pressure setting within the recommended range for the application.
- Spray the measured course.
- Refill the tank to the known level, measuring amount of water required.
- Measure the swathwidth sprayed in feet.

When broadcast spraying, the swathwidth in feet is the number of nozzles on the boom multiplied by the nozzle spacing in inches and divided by 12. When band spraying, the swathwidth in feet is the number of bands multiplied by the bandwidth in inches and divided by 12.

The application rate in gallons per acre may now be calculated by this formula.

$$GPA = \frac{43{,}560 \times \text{gallons used}}{\text{length} \times \text{swathwidth}}$$

- GPA means gallons per acre or gallons of pesticide-water mixture applied per acre.
- 43,560 is the number of square feet in 1 acre.
- Gallons used is the number of gallons sprayed on the measured course to the nearest 1/10 gallon.
- Length is the number of feet in the measured course.
- Swathwidth is the width sprayed over the measured course in feet.

In this example of broadcast spraying, 6 gallons and 2 quarts or 6.5 gallons were sprayed. The measured course is 660 feet long. The boom has 13 nozzles spaced on 20-inch centers for a swathwidth of 21.7 feet.

$$\text{swathwidth} = \frac{\text{number of nozzles} \times \text{nozzle spacing}}{12}$$

$$\text{swathwidth} = \frac{13 \times 20}{12}$$

$$\text{swathwidth} = 21.7 \text{ feet}$$

Substituting in the formula, the application rate is 19.8 gallons per acre.

$$GPA = \frac{43{,}560 \times \text{gallons used}}{\text{length} \times \text{swathwidth}}$$

$$GPA = \frac{43{,}560 \times 6.5}{660 \times 21.7}$$

$$GPA = 19.8$$

In this example of band spraying, 2 gallons and 3 quarts (2.75 gallons rounded to 2.8 gallons) were sprayed. The measured course is 660 feet long and six rows are sprayed with 12-inch bands for a swathwidth of 6 feet.

$$\text{swathwidth} = \frac{\text{number bands} \times \text{bandwidth}}{12}$$

$$\text{swathwidth} = \frac{6 \times 12}{12}$$

$$\text{swathwidth} = 6 \text{ feet}$$

Substituting in the formula, the application rate is 30.8 gallons per acre.

$$GPA = \frac{43{,}560 \times \text{gallons used}}{\text{length} \times \text{swathwidth}}$$

$$GPA = \frac{43{,}560 \times 2.8}{660 \times 6}$$

$$GPA = 30.8$$

Stationary method

Another sprayer calibration method is a stationary method, calculated by determining rate by nozzle output per minute.

Determine sprayer speed in miles per hour as the first step in this method. To do this, measure a distance of 300 feet in the field to be sprayed. Time, in seconds, how long it takes to travel the distance at the desired spraying speed. To calculate the speed in miles per hour, divide 204 by the number of seconds to travel 300 feet.

$$\text{miles per hour} = \frac{204}{\text{seconds to travel 300 feet}}$$

With the tank filled with water and the sprayer stationary and operating at the pressure to be used in the field, catch and record the sprayer discharge in ounces for 1 minute from each nozzle. Calculate the average nozzle discharge per minute by adding the discharge from each nozzle and dividing by the number of nozzles. Calculate the application rate in gallons per acre for broadcast spraying by this formula.

$$GPA = \frac{\text{ounces per minute}}{\text{nozzle spacing} \times \text{MPH}} \times 46.4$$

. GPA means gallons per acre or gallons of pesticide-water mixture applied per acre.

. Ounces per minute is the average nozzle discharge in ounces per minute.
. Nozzle spacing is the distance in inches between nozzles.
. MPH is the sprayer speed in miles per hour.
. 46.4 is a constant used in the formula.

In this example of calculating sprayer speed, it takes 51 seconds to travel 300 feet. Divide 204 by 51 for a speed of 4 miles per hour.

$$\text{miles per hour} = \frac{204}{\text{seconds to travel 300 feet}}$$

$$\text{MPH} = \frac{204}{51}$$

$$\text{MPH} = 4$$

In this example of broadcast spraying, the average nozzle discharge is 35 ounces per minute, nozzles are spaced on 20-inch centers and the sprayer speed is 4 miles per hour. Substituting in the formula, the application rate is 20.3 gallons per acre.

$$\text{GPA} = \frac{\text{ounces per minute}}{\text{nozzle spacing x MPH}} \times 46.4$$

$$\text{GPA} = \frac{35}{20 \times 4} \times 46.4$$

$$\text{GPA} = 20.3$$

The application rate in gallons per acre for band spraying may be calculated by this formula.

$$\text{GPA} = \frac{\text{ounces per minute}}{\text{bandwidth x MPH}} \times 46.4$$

All parts of the formula are the same as for broadcast spraying except bandwidth in inches is substituted for nozzle spacing.

In this example of band spraying, the average nozzle discharge is 31 ounces per minute, bandwidth is 12 inches and the sprayer speed is 4 miles per hour. Substituting in the formula, the application rate is 30 gallons per acre.

$$\text{GPA} = \frac{\text{ounces per minute}}{\text{bandwidth x MPH}} \times 46.4$$

$$\text{GPA} = \frac{31}{12 \times 4} \times 46.4$$

$$\text{GPA} = 30$$

Many calibration methods may be used. Just remember to calibrate equipment before every use.

To increase sprayer application rate slightly, decrease groundspeed or increase pressure or both. To decrease the application rate slightly, decrease

pressure or increase groundspeed or both. To make big changes in application rate, change the size of nozzle tips.

Recalibrate sprayers often to determine changes in application rate because of nozzle wear. Manufacturers provide tables showing relationship between speed pressure and gallons per acre that help simplify nozzle selection and calibration.

Principles used to calibrate sprayers also may be used to calibrate granular applicators. Output over a known area may be caught and weighed, or the amount applied may be replaced, weighing the amount it takes. Knowing the amount applied over the known area, the amount used per acre may be calculated.

Pesticide mixing

Few pesticides are available as pure material and recommendations often are written in terms of active ingredient, not the product's total volume. Further confusion is added if recommendations are in terms of pounds per acre with the product packaged in gallons or listed by percentage.

Use this formula to calculate the pounds of purchased material to be used per acre.

$$\frac{\text{pounds active ingredient per acre}}{\text{percent active ingredient}} = \text{pounds of purchased material to use per acre}$$

Divide the pounds of active ingredient needed per acre by the percent active ingredient in the formulation.

In this example, a 50 percent wettable powder is to be applied as 1 pound of active ingredient per acre. A 50 percent wettable powder means that 50 percent of the formulation is active ingredient. Substituting in the formula 2 pounds of 50 percent wettable powder are needed per acre to get 1 pound active ingredient per acre.

$$\frac{\text{pounds active ingredient per acre}}{\text{percent active ingredient}} = \text{pounds of purchased material to use per acre}$$

$$\frac{1}{.50} = 2 \text{ pounds per acre}$$

To determine the gallons of purchased material to use per acre, use this formula.

$$\frac{\text{pounds active ingredient per acre}}{\text{pounds active ingredient per gallon}} = \text{gallons of purchased material to use per acre}$$

Divide the pounds of active ingredient to be applied per acre by the pounds of active ingredient per gallon.

In this example, the pesticide contains 4 pounds of active ingredient per gallon, and 2 pounds of active ingredient are needed per acre. Substituting in the formula, ½ gallon of purchased material is used per acre to get 2 pounds active ingredient per acre.

$$\frac{\text{pounds active ingredient per acre}}{\text{pounds active ingredient per gallon}} = \text{gallons of purchased material to use per acre}$$

$$\frac{2}{4} = .5 \text{ gallons per acre}$$

After determining application rate in gallons per acre and the number of pounds or gallons of purchased material to apply per acre when using a sprayer for pesticide application, the pounds or gallons per tank of mixture may be calculated. First, determine the number of acres a tank will treat. This is done by dividing the number of gallons in the tank by the gallon-per-acre application rate.

$$\text{acres tank will treat} = \frac{\text{gallons in tank}}{\text{gallons per acre application rate}}$$

The amount of purchased material to add to the tank is determined by multiplying the acres the tank will treat by the amount of purchased material to apply per acre.

$$\text{purchased material to put in tank} = \text{acres tank will treat} \times \text{purchased material per acre}$$

In this example, ½ gallon of purchased pesticide is to be applied per acre with an application rate of 25 gallons per acre. The tank holds 200 gallons so when dividing 200 by 25, the tank will treat 8 acres.

$$\text{acres tank will treat} = \frac{\text{gallons in tank}}{\text{gallons per acre application rate}}$$

$$\text{acres tank will treat} = \frac{200}{25}$$

$$\text{acres tank will treat} = 8$$

By multiplying 8 by ½, 4 gallons of purchased material are needed in the tank.

$$\text{purchased material to put in tank} = \text{acres tank will treat} \times \text{purchased material per acre}$$

$$\text{purchased material to put in tank} = 8 \times \tfrac{1}{2} \text{ gallon}$$

$$\text{purchased material to put in tank} \times 4 \text{ gallons}$$

Partially fill the tank, add 4 gallons of pesticide and finish filling the tank to 200 gallons.

In this example, 2 pounds of purchased wettable powder are to be applied per acre with an application rate of 25 gallons per acre. The tank holds 200 gallons so when dividing 200 by 25, the tank will treat 8 acres.

$$\text{acres tank will treat} = \frac{\text{gallons in tank}}{\text{gallons per acre application rate}}$$

$$\text{acres tank will treat} = \frac{200}{25}$$

$$\text{acres tank will treat} = 8$$

By multiplying 8 times 2, 16 pounds of wettable powder are needed in the tank.

$$\begin{matrix}\text{purchased material} \\ \text{to put in tank}\end{matrix} = \begin{matrix}\text{acres tank} \\ \text{will treat}\end{matrix} \times \begin{matrix}\text{purchased material} \\ \text{per acre}\end{matrix}$$

$$\begin{matrix}\text{purchased material} \\ \text{to put in tank}\end{matrix} = 8 \times 2 \text{ pounds}$$

$$\begin{matrix}\text{purchased material} \\ \text{to put in tank}\end{matrix} = 16 \text{ pounds}$$

Fill the tank about half way and start the sprayer to begin tank agitation. Mix the wettable powder in a bucket with a little water. Stir into a slurry and then add to the tank. Next, finish filling tank.

For control of floating vegetation and shoreline vegetation, chemical amounts are computed on a per-acre basis.

For treatment of submersed weeds or algae, it is usually necessary to calculate the total water volume in acre feet. An acre foot of water is defined as 1 acre of water 1 foot deep. If the pond is less than 1 acre in size, multiply the length of the pond times the width of the pond times the average depth of the pond all in feet. Divide the results by 43,560 to calculate the volume of the pond in acre feet.

## REVIEW QUESTIONS

### GROUND APPLICATION

1. How many pounds of active ingredient are in 10 pounds of an 80 percent wettable powder formulation?

   a) 4 b) 8 c) 6 d) 2

2. Before calibrating a boom field sprayer, the discharge from each nozzle should be checked. Replace the tip in any nozzle that has a flow rate of _____ percent more or less than the average of the nozzles in the system.

   a) 10 b) 20 c) 30

3. Sprayer nozzles control which of the following?

   a) Amount of material applied
   b) Droplet size
   c) Spray pattern
   d) All of the above

4. A 75 percent wettable powder is to be applied as 3 pounds of active ingredient per acre. How many pounds of 75 percent wettable powders are needed per acre?

   a) 6 b) 4 c) 12 d) 2

5. A spray solution application rate will be 25 gallons per acre. How many acres of crop can be sprayed broadcast if the sprayer has a 300 gallon tank?

   a) 24 b) 12 c) 6 d) 10

6. Sprayer nozzles should be cleaned with:

   a) a steel brush
   b) a toothbrush
   c) a clean knife
   d) all of the above

7. A sprayer's application rate may be increased slightly by which of the following?

   a) increase groundspeed
   b) increase pressure
   c) decrease groundspeed
   d) decrease pressure

## PESTICIDE SAFETY

Pesticides, predominately organic chemicals, are toxic to various pests (insects, weeds and causal organisms of plant disease, etc.). Many are toxic also to nontarget organisms including man. Safe and proper use depends partly on knowledge of toxic properties and a respect for the potential hazards associated with their use. Misuse of pesticides may cause or create problems not only for the applicator but for others as well. Potential problems include poisoning the applicator or others from mishandling and poor storage, drifting onto susceptible crops, pesticide residues in excess of established tolerance, carry-over effects, etc.

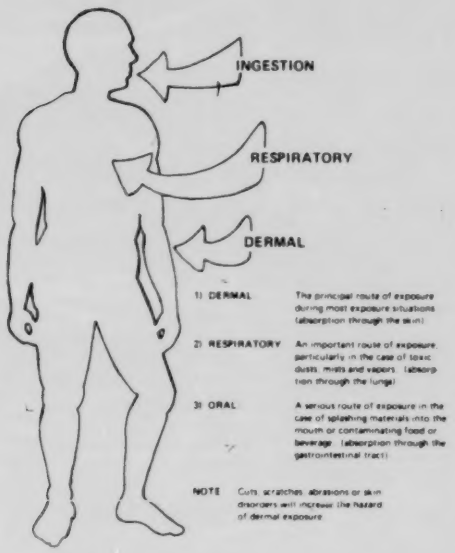
Proper handling, use, storage and disposal; recognition of local environmental situations and poisoning symptoms and procedures to follow in the case of pesticide poisoning are each essential elements of safe use.

The importance of the product label as an information source is a key element of safe use. Precautionary statements; hazards to man, domestic animals and the environment; reentry statements and storage and disposal information, all a part of the label, are guides to safe use.

Remember, few safety recommendations cover all situations. There are, however, some general guidelines that, if followed along with the information on the product label, are beneficial when using pesticides. Some points worth remembering include the following information:

Chemicals used as pesticides are poisonous and one must exercise care in their handling and use to avoid accidental poisoning; damage or irritation to the skin or eyes and damage to crops, livestock and the environment. Safe pesticide use begins with purchase, continues through proper use and is complete with proper disposal of waste and the used container.

The key to preventing accidental poisoning is an awareness of the route by which pesticides may enter the body. Use hazards depend on a product's toxicity and degree of exposure. Safety instructions on the label and from other sources become more meaningful if one understands the reasons for the instructions.


INGESTION
RESPIRATORY
DERMAL
1) DERMAL The principal route of exposure during most exposure situations (absorption through the skin)
2) RESPIRATORY An important route of exposure, particularly in the case of toxic dusts, mists and vapors. (absorption through the lungs)
3) ORAL A serious route of exposure in the case of splashing materials into the mouth or contaminating food or beverage. (absorption through the gastrointestinal tract)
NOTE Cuts, scratches, abrasions or skin disorders will increase the hazard of dermal exposure.

Pesticides may enter the body through the skin, lungs or mouth. Entry through the skin is the most likely source of poisoning during handling and use of a pesticide. Pesticides contact the skin through spills, spray droplets, dust or from equipment.

Mixers, loaders and flaggers are subject to relatively high levels of skin exposure. Indoor spraying can be extremely hazardous because of the

possibility of increased skin exposure. Poisoning from contact with treated plant surfaces has occurred. Hand harvesting, thinning, cultivating, irrigating and insect scouting can result in sufficient skin exposure to cause poisoning. Additional exposure may result from contact with the contaminated surfaces of equipment.

Skin exposure is minimized by using protective equipment. No safety recommendations cover all situations. Check the label for specific recommendations for protective clothing and equipment.

As a general rule, use clean clothing daily and cover up before exposure, not afterward. Covering contaminated skin increases absorption of some pesticides. A long sleeved shirt and full length trousers or coverall-type garment made of closely woven material are minimum requirements. A wide brimmed hat, preferably waterproof, offers protection from downward drift for face and neck areas. Plastic "hard hats" also are useful. Contaminated hatbands can be a source of exposure. Use disposable hatbands or hatbands of a material that can be cleaned readily.

Wear unlined, natural rubber gloves for best protection. Prevent contamination of the inside of the gloves. Loose long sleeves should cover the gauntlet of the glove to keep pesticides from running down into the glove. For some pesticides, such as methyl bromide, gloves are not to be used. This is one more reason to consult the product label before using a pesticide.

If exposure to the lower trunk and legs is anticipated, such as in mixing and loading, a waterproof apron is essential. Waterproof shoes or boots are preferred. Leather shoes crack after a few wettings and, thus, are penetrated

easily. Canvas shoes offer little protection. Contaminated shoes or boots are another source of exposure. Wear trouser legs over boots to keep pesticides from running down the trousers into the boots.

Shield the eyes to avoid exposure, particularly if splashing may occur, such as in mixing and loading. Goggles or a face shield provide protection.

If clothes become wet with spray or if pesticide is splashed onto clothing or the skin, remove the clothing and wash immediately. Decontamination of the skin is more efficient if done promptly. Destroy heavily contaminated clothing. Do not store or wash contaminated clothing with the family laundry.

Proper care of protective clothing is essential. Test gloves for leaks. Wash gloves, boots, hat, goggles and face shield following each day's use and more often if necessary due to excessive contamination.

Pesticides also may enter the body through the lungs. The mouth is another point of entry followed by absorption through the gastrointestinal tract. While exposure through these routes generally is less likely than skin exposure, the pesticide is absorbed much more efficiently through these routes.

Various types of respirators can provide respiratory protection. Most respirators are air purifying and remove contaminants from air by filtering or chemical action.

Filters remove particles by physical trapping as air is inhaled. Mechanical filters do not provide protection against gases, vapors or oxygen deficiency.

A respirator is characterized by a cartridge or canister which contains a chemical that removes gases or vapors.

Read the label. If a respirator is required, the information will appear on the label. In fumigation or applying highly toxic pesticides in confined spaces, a respirator with a special compressed air supply tank is suggested.

No matter how well a respiratory device is designed and made, unless it is maintained properly, it may fail to provide protection. The most common problems are failure to occasionally wash the face piece with soap and water and neglecting to change the filter cartridges. Check the face piece for cracks, hardening and elasticity of straps. A good seal is essential.

Change filters twice a day and whenever breathing becomes difficult. Change cartridges after 8 hours of actual use and whenever any pesticide odor is detected.

Remove filters and cartridges and wash the face piece with soap and water after use. Rinse thoroughly to remove traces of soap. Dry with a clean

cloth that is not contaminated with the pesticide and place the face piece in a well-ventilated area to dry. Store the respirator, filters and cartridges in a clean, dry place, preferably a tightly closed paper or plastic bag.

Accidental splashing or transfer of pesticides to the mouth through wiping one's face on the sleeve, cuff or hand are likely ways pesticides can enter the mouth. Other possibilities include food handled with contaminated hands; food exposed to pesticide spray, dust or spills; contaminated drinking utensils and attempting to clear nozzles by blowing through them.

Check the label for special instructions or warnings regarding exposure. Never eat, drink or smoke while spraying or dusting. Wash thoroughly with soap and water before eating or drinking. Do not touch lips to contaminated objects or surfaces.

Do not wipe the mouth with hands, forearm or clothing. Do not expose lunch, lunch container, beverage or drinking vessel to pesticides. If involved in operations that may result in splashing pesticides, wear a full-face shield.

Information regarding signs and symptoms of poisoning often is a part of the pesticide label. Signs and symptoms of organophosphorus poisoning may include fatigue, headache, dizziness, blurred vision, excessive sweating, nausea and vomiting, stomach cramps and diarrhea. Repeated exposures over a brief period of time may result in poisoning, all the more reason for minimizing exposure.

Signs and symptoms of moderate organophosphorus poisoning include inability to walk, weakness, chest discomfort, muscle twitches and constriction of the pupils of the eye.

Severe organophosphorus poisoning results in unconsciousness, severe pupil constriction, muscle twitches, secretions and breathing difficulty.

Signs and symptoms of carbamate poisoning are similar to those of organophosphorus poisoning. These include feelings of discomfort, excessive sweating, light-headedness, nausea, blurred vision and excessive salivation and vomiting.

Toxicity of organophosphorus and carbamate pesticides relate primarily to their function as cholinesterase inhibitors. Acetycholinesterase is an enzyme involved in the normal function of certain nerves. Regulation of vital body processes such as breathing, pulse rate and function of the gastrointestinal tract, for example, are controlled by nerves. Following a nerve impulse, the nerve or junction is returned to the normal state in the presence of an enzyme (acetylcholinesterase) and is again capable of carrying an impulse. The enzyme (acetylcholinesterase) prevents persistent "activation" of the nerve or junction. Certain chemicals including organophosphorus and many carbamate pesticides block the enzyme action (acetylcholinesterase) causing a nerve malfunction.

Failure of the affected nerves to function properly causes:

. Constriction of the pupil of the eye (miosis)
. Tightness of the chest

. Increased bronchial (respiratory tract) secretions
. Sweating
. Tearing (lacrimation)
. Rapid pulse rate initially followed by a decrease in the pulse rate
. Nausea, vomiting, abdominal pain and diarrhea
. Involuntary urination
. Muscle twitching
. Cramps
. Increased salivation

A lethal dose of a cholinesterase-inhibiting organophosphorus compound is reported to produce death from respiratory failure (asphyxia).

Clinically, poisoning from cholinesterase-inhibiting organophosphorus or carbamate pesticides is confirmed by measuring the cholinesterase activity of the blood plasma or red blood cells (erythrocytes). Persons working with organophosphorus or carbamate pesticides which interfere with normal nerve functions (inhibitors of the enzyme acetylcholinesterase) should consult a physician concerning the possibility of measuring blood cholinesterase activity as an estimate of exposure. Specific antidotes, available to the medical profession, are effective in countering organophosphorus and carbamate pesticides.

Although the symptom-producing effect of organophosphorus poisoning results from blocked activity of the enzyme at the nerve or nerve ending, the enzyme also exists in tissues and blood. This enzyme serves as a buffer or reserve "tying up" much of the toxic material even though some affects the enzyme at the nerve or nerve ending. Thus, reduction of blood and tissue enzyme by repeated exposure to the poison reduces the reserve, and the critical enzyme at the nerve and nerve junctions is affected more readily.

Exposure of a significant nature is likely to produce less severe poisoning if the reserve is not depleted. Thus, even in the absence of noticable effects, always attempt to minimize exposure.

Toxicity to man and other warm-blooded animals varies greatly within a given group or class of compounds, particularly those used as insecticides. For example, some organophosphorus insecticides are direct inhibitors of acetylcholinesterase, while others are inactive *per se* but are changed in the body of man and other organisms to one or more toxicants that are inhibitors of acetylcholinesterase. The net toxic effect depends on a combination of factors including the rates of activation and/or detoxification, penetration to the site of action and the affinity of the toxicant for acetylcholinesterase.

Signs and symptoms of chlorinated hydrocarbon pesticide poisoning vary but may include nausea, mental confusion or semiconsciousness, jerking of the legs and arms, dizziness, drowsiness, weakness and loss of appetite.

Signs and symptoms of fumigant and solvent poisoning include poor coordination, slurred speech, confusion and sleepiness. Become familiar with the signs and symptoms of poisoning produced by the products you use and with the "statement of practical treatment" or first aid on the pesticide products you use. This

information may save your life or the lives of others. A statement of practical treatment, first aid or other appropriate practical treatment is a part of most pesticide labels. Before using a pesticide, become familiar with specific first aid information on the product label.

Some pesticide labels will include information regarding signs and symptoms of poisoning. Pesticide poisoning signs may appear like brain hemorrhage, heat stroke, heat exhaustion, low blood sugar, gastroenteritis, asthma and pneumonia. If you should become ill or experience any signs or symptoms, seek medical help immediately.

Criteria for cataloging pesticide products by toxicity established by federal regulation include the following categories based on the acute oral $LD_{50}$ of the product:

| | |
|---|---|
| Highly toxic | $LD_{50}$ - 50 mg/kg or less |
| Moderately toxic | $LD_{50}$ - Between 50-500 mg/kg |
| Low order toxicity | $LD_{50}$ - 500-5000 mg/kg |
| Comparatively free from danger | $LD_{50}$ - 5000+ mg/kg |

A product with an acute dermal $LD_{50}$ of 200 milligrams or less per kilogram of body weight when administered by continuous contact for 24 hours to the bare skin of rabbits is considered highly toxic to man.

$LC_{50}$ is the term used to identify a product's concentration in air that is fatal to 50 percent of the test animals when administered by continuous inhalation for 1 hour to both male and female rats or in some cases other species. A pesticide that exhibits an acute $LC_{50}$ value of 2,000 micrograms or less of dust or mist per liter of air or 200 parts per million or less by volume of gas or vapor is considered highly toxic to man.

In each case, the acute oral $LD_{50}$, dermal $LD_{50}$ and $LC_{50}$ is evaluated on the basis of death produced in 50 percent of the test animals within 14 days of the challenge.

$LD_{50}$ values have become a universally accepted means of expressing toxicity. Acute oral $LD_{50}$ values provide a means of comparing one chemical to another and thus a means of evaluating the relative toxicity of chemicals when administered orally. Many people are tempted to use the values in an absolute sense, i.e., direct extrapolation of $LD_{50}$ to man even to the point of calculating the $LD_{50}$ dose for man. Relevance of these animal values to man is questionable. Further assumption could lead to serious consequences. One should assume in the absence of information to the contrary, that the chemical is at least as toxic to man as it is to the most sensitive test animal. Effects of pesticides on the eye and skin also are considered criteria in cataloging pesticide products by toxicity.

Of the various work activities associated with pesticide use, the loading operation is considered one of the more hazardous parts of the spraying or dusting cycle. Obviously, many factors are involved that determine the degree

of hazard of any operation. Mixing and loading pesticides generally results in exposure to higher concentrations and greater quantities (i.e., spills, splashes, etc.). Although not minimizing the importance of protective measures during all work activities, the mixing and loading operation warrants special attention and care.

Consider the following general safety instructions during mixing and loading:

- Never work alone when handling hazardous pesticides.
- Mix chemicals outside where there is adequate ventilation.
- Following the label carry out calculations for required dilution and obtain proper equipment, including protective clothing, proper respirator, if required, and first aid equipment. A waterproof apron is especially useful in protecting the lower trunk and legs.
- Check all figures and calculations for each load.
- Have clean measuring and transfer containers available. Transfer containers must have a spout for pouring the concentrate and separate openings for fill and venting. All measuring and transfer containers should be galvanized or of stainless steel for safety unless plastic or other containers are specified on the product label. Many pesticides are corrosive or react with other chemicals, water or some metals. Paint all mixing and loading containers a bright orange and label "Danger - Poison" to prevent their use for other purposes.
- Carefully open original concentrate containers. Open sacks with a knife rather than tearing. Always stand upwind when mixing or loading pesticides.
- Pour concentrate into the measuring container. Touch the spout of the concentrate container to the edge of the measuring container before pouring the liquid. Replace the lid on the concentrate container.
- Pour the concentrate from the measuring container into the transfer container. Touch the spout of the measuring container to the edge of the opening of the transfer container before pouring the liquid. Repeat the two preceding steps for each load using a separate transfer container for each load.
- Replace the lids tightly on the transfer containers.
- Rinse measuring containers. Return concentrates, empty containers and clean measuring containers to the chemical storage room.
- With the transfer containers in position for emptying into the spray tank, remove the spout lid, loosen the outer lid so it will function as a vent and carefully pour the concentrated pesticide into the tank without splashing. If the spray tank is elevated, do not allow others in the immediate vicinity at ground level.
- As concentrate containers are emptied in the process of measuring, allow them to drain in a vertical position for 30 seconds.
- As concentrate containers are emptied and drained, use water or other diluting material to rinse the container. Rinse three times allowing 30 seconds for cleaning after each rinse. (Use 1 quart for each rinse of a 1-gallon can or jug, a gallon for each 5-gallon can and 5 gallons for either 30- or 55-gallon drums.)
- Tighten both lids (spout and vent) of transfer containers before returning the container to ground level. Thoroughly rinse transfer containers before they are returned to the locked chemical storage room.

Be sure to:

. Always mix outside in open air.
. Handle carefully to minimize splashing.
. Remove the screen on the spray tank before adding the concentrate.
. Slurry wettable powders before adding to the spray tank.
. Do not mix chemicals unless specified by label directions.

Back-siphoning, which occurs through pumps commonly used to deliver liquids, results in water contamination. In this manner pesticides can be back-siphoned from the spray or mixing tank to the nurse tank, ponds, streams, wells and other water systems.

When delivering water to spray or mixing tanks, use an air gap and a check valve to prevent back-siphoning. The distance between the hose and the top of the tank should be two times the diameter of the hose.

Always store pesticides in original containers with a legible label. Keep storage unit away from food, feed or clothing; away from living quarters and in an area not subjected to temperature extremes or high moisture conditions.

Proper storage protects the health and well-being of people, pets and livestock; protects against environmental contamination and often extends a chemical's shelf life. Take special care to handle and store pesticides to prevent fire hazards and explosion. Fires involving pesticides present uncommon hazards, for example, highly toxic and phytotoxic fumes, toxic runoff and toxic ash or other residues.

When storing pesticides place in a well-ventilated area preferably in a separate building. Do not locate storage near food, feed or seed. Post signs at each entry and on all sides of the storage building. Keep the storage area locked when not in use; keep a log of pesticides and the amount of each in storage. Fireproof the area to the extent possible; check containers periodically for corrosion, leaks, breaks and tears and store "empty" containers in the storage area pending proper disposal.

Use the rinse and drain procedure to decontaminate "empty" pesticide containers and to minimize waste. For a pesticide costing $70 a gallon, the dollar loss from unremoved material amounts to $3.50 per 5-gallon can and up to $17.50 per 55-gallon drum. An empty pesticide container that has not been rinsed is far from being empty. This results in increased hazards to the environment, humans and animals, plus additional material cost and less efficient pest control.

When following label directions for disposal such as burning paper or cardboard containers where permitted, stay out of smoke. Do not allow smoke to drift onto crops or onto areas occupied by humans or animals. Suggested safety procedures are not intended as a substitute for specific information appearing on each pesticide product label. Few safety recommendations cover all situations so always read the label.

Using pesticides in ways other than directed on the label can:

. Injure plants and animals

. Leave illegal residues
. Create greater pest problems
. Damage wildlife and fish

Insure that pesticide use does not create environmental problems.

Pesticides become problems when they move off target. This may mean drifting out of the target area as a mist or dust; moving through runoff and erosion; leaching through the soil; being carried out as residues in crops, livestock or livestock products or evaporating and moving with air currents.

To minimize drift, use the largest droplet spray consistent with effective pest control, and avoid spraying upwind from sensitive crops or pastures. Avoid spraying during high wind or air stagnations. Conditions that hold smoke close to the ground (a warm air ceiling near ground level) allows drifting small droplets to remain close to the ground; slowly settling droplets may concentrate on nearby crops.

Most fish and other aquatic organisms can survive only slight environmental changes. Very small amounts of many pesticides harm them or destroy the food they eat. They may die immediately or change effects may exist which make them more susceptible to prey or interfere with normal reproduction.

Pesticides may reach water directly through application, drift, spills or incorrect disposal methods and indirectly through runoff, leaching and air cleansing rains.

Proper pesticide selection, handling, use and disposal minimizes pesticide problems in the environment.

## REVIEW QUESTIONS

## PESTICIDE SAFETY

1. Use hazards may be estimated based on

   a) manufacturer's identity
   b) product toxicity
   c) degree of exposure
   d) EPA registration number

2. Pesticides may enter the body through

   a) the skin
   b) the lungs
   c) the digestive tract
   d) all of the above

3. The prime source of information about a pesticide product and its safe use is the

   a) Environmental Protection Agency
   b) product label

c) Texas Department of Health Resources
d) individual who has used the product on previous occasions

4. Mechanical filter type respirators

a) remove particles by physical trapping
b) remove vapors and gases
c) protect against oxygen deficiency

5. The toxicity of organophosphorus and carbamate pesticides to man relates primarily to

a) formulation
b) their function as cholinesterase inhibitors
c) product stability

6. Pupil contriction is a sign of

a) organophosphorus poisoning
b) carbamate poisoning
c) organochlorine poisoning
d) solvent poisoning

## PESTS AND PEST DAMAGE

Pests normally associated with plants and animals include insects, parasites, plant disease, weeds, brush and animals such as rodents, predators and birds. Knowledge of the pest and its damage is the essential first step in managing a pest problem. All management decisions that follow can be made correctly only if the problem has been diagnosed properly. Initially identification of pests is based primarily on observations of either the pest, its damage or signs of damage. Later identification is made through the process of elimination with a knowledge of hosts, the pests, damage, time of year, etc.

Plants may be injured by a variety of pests, including insects, mites, fungi and animals. Weeds and brush compete with plants for available moisture, plant nutrients and space. Livestock, poultry and other animals are subject to attack by internal and external parasites. However, plants also are susceptible to injury by drought, hail, nutritional deficiences and chemicals such as certain air pollutants. Similarly, livestock, poultry and other animals are subject to disease and nutritional disorders. Two or more causes may produce signs and symptoms so similar that the exact cause may be difficult to distinguish. In fact, plant disease-causing organisms and nematodes are identified only by experts with the aid of a microscope.

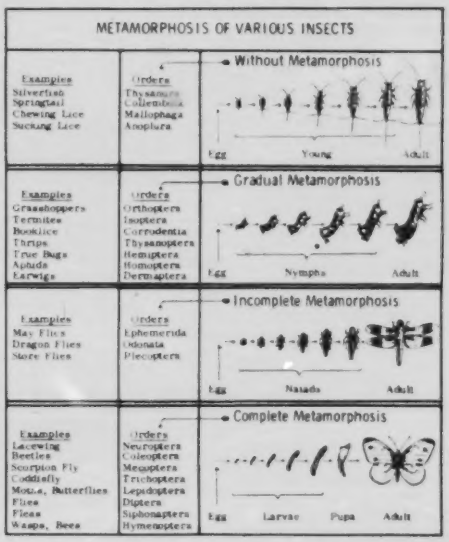
Thus, we see the need for identifying pests and pest damage which is included in the federal standard for commercial applicators. A review of the common as well as some of the unique considerations involved in pest identification, damage caused by pests and pest control may be beneficial.

## Insect pests

Insects, found almost everywhere on the face of the earth, damage virtually anything of value to man.

Insect pests feed on leaves, stems, stalks, branches, seeds, fruits and nuts. Or, they suck sap from leaves, stems, roots, fruits and flowers. Some also attack wearing apparel or carry disease agents of man, animals and plants.

To solve an insect pest problem, you must first identify it. Identification is easier if you know something about insects.

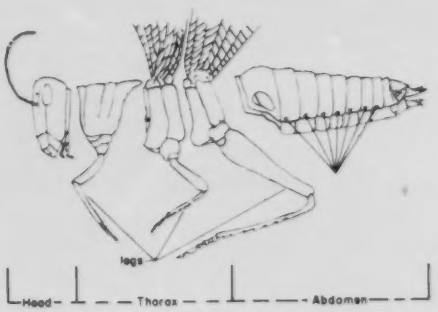



Most insects change form and size as they grow to adults. Some, such as silverfish, sucking and chewing lice and collembola, only increase in size from immature to adult stages. Others, such as the Harlequin bug, increase in size primarily, but the adults are winged. This growth is typical of grasshoppers, aphids, termites, booklice, true bugs, etc.

With insects having complete metamorphosis, the immature stages and adults differ considerably in appearance, habitat and food preferences in many cases. This growth is typical of the Mexican bean beetle as well as other beetles, moths, butterflies, flies, fleas, wasps, bees, etc.

All adult insects have two things in common:

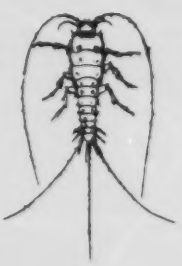
- Three pairs of jointed legs
- Three body regions
  - -Head
  - -Thorax
  - -Abdomen




You can distinguish the various adult insects by comparing their wings, mouthparts, size, shape and markings. Some (such as silverfish, chewing and sucking lice, etc.) do not have wings; others have two wings and many have four wings.

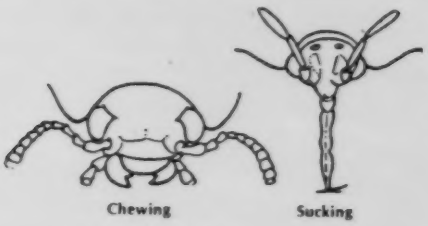
Fly (two wings)

Dragonfly (four wings)


Silverfish

Sucking louse

Chewing insects have tooth-like mouthparts used for biting, tearing or skeletonizing host tissue. Those that suck internal plant fluids or blood have needle-like, piercing mouthparts or beaks.

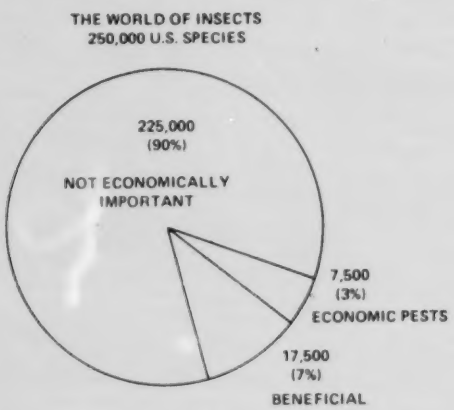



Types of mouthparts

Close relatives of the insects are mites, ticks and spiders, but there are important differences. Adult mites, ticks and spiders have eight legs, not six. They are wingless and have only two body regions:

. Combined head and thorax
. Abdomen

More than 250,000 kinds or species of insects occur in the U.S. The many insects (including spiders, ticks and mites) are commonly grouped in three categories according to their impact on man.




The largest category, comprising more than 90 percent of the insects includes those commonly recognized as having essentially no direct detrimental or beneficial influence on man. They provide food for fish, birds, amphibians, skunks, bats, armadillos and other animals in the intricate food chain of nature. Insects are also nature's scavengers.

The second largest insect group comprises those classified as beneficial. Many spiders, mites and insects are either parasites or predators of destructive species. These beneficials provide important natural control of economically important pests. In their absence, man would be unable to cope with his insect problems.

Included in this group are lady beetles, tiger beetles, parasitic wasps, lacewing fly larvae, most spiders and many others. Also in this category are the insect pollinators--bees, wasps, ants, butterflies, certain beetles, flies and thrips. Their economic value to man exceeds several billion dollars annually.

Economically important or destructive species fall in the third and smallest category. This group includes fewer than 3 percent of the known U.S. species. Of this number only 150 to 200 regularly cause economic damage. An additional 400 to 500 species are sporadic pests. Another 6,000 are minor pests classed as nuisance pests but cause no real economic or health damage.

It is fortunate that the number of economically destructive pests is small, otherwise man would be seriously challenged to control them. This fact also

indicates the importance of clearly and accurately identifying a pest problem. Effective, economical control depends on your accuracy.

Pest control

Natural control of pest species accounts for more than 99 percent of the reduction in potential insect damage. These factors include:

. Climate - temperature, rainfall, radiation or sunlight
. Physical factors - mountain ranges, seas and other water barriers and dominant plant and animal competitors
. Predators and parasites - insects, mites, spiders, nematodes, mammals, reptiles and fish
. Insect diseases - bacteria, viruses and fungi

When natural control factors fail to hold pest populations below economic damage levels man must intervene and use artificial control techniques. Knowing *when* to use a specific control measure, or combination of methods is a great challenge to those involved in pest control.

Included in man's arsenal of artificial controls are:

. Mechanical and physical methods
. Cultural methods
. Biological control
. Legal control
. Genetic control
. Chemical control

Pest categories

Most insect pests fall into three basic categories:

. Key pests
. Occasional pests
. Secondary pests

*Key pests* are the insects or mites which cause constant economic losses almost annually. *Occasional pests* infrequently cause economic losses generally under a specific set of weather or cropping conditions.

*Secondary pests* are occasional pests or non-pests which cause economic losses due to a man-made disruption such as the destruction of natural enemies including parasites or predators, through the misuse of an insecticide which allows the pest population to develop unrestricted in the absence of its natural enemies.

Economic threshold--when to treat

An insect pest must be present in sufficient numbers and cause a certain level of damage to justify control expenses. The mere presence of an insect pest does not necessarily result in lower quality or quantity of an agricultural commodity or an animal product. The term "economic threshold" is used frequently to denote that point in the development of a pest population or the damage level caused by a pest which warrants the application of a control measure, such as an insecticide.

This term means the largest number of insects and/or damage tolerable before economic injury or loss occurs. Economic thresholds have been determined for many insect pests on Texas' crops and livestock. A few examples are discussed in the following paragraphs.

For boll weevil on cotton 15 to 25 percent of the 1/3 grown squares must have boll weevil egg-laying punctures before economic damage occurs.

**Table 1. Economic threshold for boll weevil**

| Crop | Pest | Economic threshold or "when to treat" |
|---|---|---|
| Cotton | Boll weevil | When 15 to 25 percent of the one-third grown squares have weevil egg-laying punctures and the cotton has not set a full "boll load" |

The sorghum midge is a key pest of grain sorghum. Several factors, however, must be considered in determining whether insecticides are needed to prevent economic damage. When 25 to 30 percent of the heads are in bloom, economic damage occurs when adult midge numbers average more than one per head.

**Table 2. Economic threshold for sorghum midge**

| Crops | Pest | Economic threshold or "when to treat" |
|---|---|---|
| Grain sorghum | Sorghum midge | When 25 to 30 percent of the heads are in bloom and the number of adult midges average more than one per head |

The greenbug also is a key pest of grain sorghum. The economic threshold for this aphid varies with plant size and maturity.

**Table 3. Economic threshold for greenbug**

| Crop | Pest | Plant age or maturity | Economic threshold or "when to treat" |
|---|---|---|---|
| Grain sorghum | Greenbug | Seedling to 6 inches tall | Visable damage with greenbug colonies present |
| | | 6 inches tall to preboot | Before any entire leaf is killed with greenbug colonies present |
| | | Boot to hard-dough | When greenbug damage is sufficient to cause the death of more than two normal-sized leaves and greenbugs are present |

Young plants from the seedling stage to approximately 6 inches in height can suffer economic losses where visible damage plus the presence of active greenbug colonies are found. On larger plants, approximately 6 inches in height

to preboot, the economic threshold occurs just before the loss of an entire leaf plus the presence of greenbug colonies. From the boot to the hard-dough stage, plants can tolerate the loss of two normal-sized leaves with active developing greenbug colonies before chemical treatment is required.

It is apparent that not only the insect population level but the plant's age, fruiting stage, specific weather factors and activity of parasites and predators are commonly important considerations in determining the economic threshold for a particular pest and crop complex.

In agricultural systems, when the economic threshold is reached, immediate control measures are necessary to avoid or reduce economic damage. Usually this requires applying an effective, labeled insecticide. For this reason the economic threshold is equated with "when to treat" in most guidelines or publications relating to pest control.

The most important factor in determining "when to treat," based on economic thresholds, is crop or livestock inspection. Check crops or animals on a regular basis, usually weekly or more often during the pest season, to accurately determine the pest population level and the existing damage before economic thresholds can be used properly. Applying insecticides based upon economic thresholds results in dollar savings to the farmer and prevents needless insecticide applications.

Summary

In the previous discussion of insect pests, three points need reemphasizing in summary:

- Accurate pest identification is the first step in any sound pest control program. This is important because fewer than 3 percent of the insect species in the U.S. are pests.
- Use established economic thresholds or "when to treat" guidelines to determine the need for applying an artificial control. The mere presence of destructive or pest species does not mean that it will be profitable to employ one of the artificial control methods.
- Determine which control method will be most effective and return the greatest net profit.

The ability of the commercial applicator to recognize pest problems, accurately determine the damage potential and select the appropriate artificial control method, where one is required, will significantly influence the economic position of your clientele and accurately reflect on your competence as a commercial applicator.

Plant disease control

Man has had great difficulty dealing with the unseen world that he referred to as blast, blight and mildew. Robigus, "the God of Rusts," was invented to appease the spirits and prevent rust from attacking grain crops. It was probably by accident that sulfur came to be used as an effective fungicide. It represents the oldest fungicide used today.

While research has revealed the cause of disease, much confusion still exists concerning actual occurrence in people's minds. Weather often is blamed for disease, whereas it actually creates conditions that permit occurrence.

Microscopic organisms that cause disease are fungi, bacteria, nematodes and viruses. While viruses are not organisms in the truest sense, they are capable of multiplication, and these large organic particles are infectious to plants. Microscopic organisms or entities that cause disease have definite shapes. They have tremendous reproductive capacities, and this permits rapid infection when conditions are favorable.

Three factors are required for infection to occur, including a susceptible host, presence of the organism and a favorable environment. Removal of any one of these factors prevents infections. Microscopes are required to see disease-causing organisms, so another system of disease recognition must be employed. Under field conditions, symptoms are used of identify disease damage. This may be in the form of leafspots, blights, wilts or sudden death of plants. Common names of diseases and their appearance in the field will be discussed in the following material.

Control recommendations are based on practices designed to prevent specific disease conditions. For example, leafspot occurs in all peanut-producing areas annually. It is caused by a fungus that overwinters in crop residue in soil. It has a distinct appearance in the form of a circular brown-to-black spot on the leaf surface. These spots are so distinctive that they can be used to diagnose the disease without observing fungus spores that cause it. This is a great help and permits field diagnosis on the basis of symptoms.

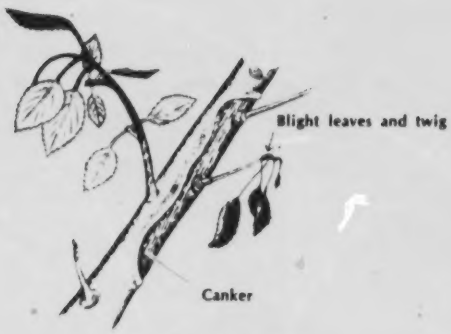
Germinating spores

Angular leafspot of cotton

Typical leafspots produced by fungi

Other types of spots are caused by bacteria, such as bacterial blight of cotton. An angular spot is formed because leaf veins restrict spread of the infection. Bolls as well as the leaves are infected. Spots appear differently on various types of plants. With southern corn leaf blight, spots usually are numerous and somewhat elongate in shape. The fungus that causes this disease is carried over in crop residue. Spores are blown by air from the point of origin and, because of the large number produced, some will land on susceptible plants.

Blight, another term used to describe disease symptoms, describes the rapid discoloration and death of tissue over certain portions of the plant.




Typical fire blight symptoms

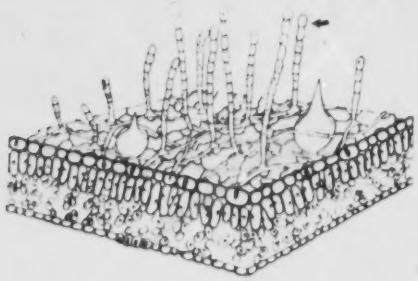
It usually kills leaves, flowers and stems as is the case with the fire blight, a bacterial disease of pears and apples.

Rots of fruit and vegetables may be caused by fungi or bacteria. Brown rot of peach is caused by a fungus capable of killing blossoms as well as rotting the fruit. Infected fruit are not edible, and fungicides must be used to prevent initial infection. Commercial fruit producers must constantly battle this problem with regularly applied protectant fungicides.

Fungicides prevent spore germination and stop the infection process. If a protective film is kept on the surface, damage can be prevented. Furthermore, fungicides must be applied so that even distribution on the foliar surface is insured.

Rusts are caused by fungi with a limited host range. A particular rust fungus usually affects only a few closely related plants. For example, leaf rust of oats does not infect wheat. Spores, the small reproductive bodies, are windborne for many miles.

Smuts occur on many crops, but again, a particular type of smut fungus only affects closely related plants. Head smut, for example, usually affects only sorghum even though corn has been affected occasionally. The grain sorghum head is replaced completely by a mass of black spores. These spores fall to the soil and permit overwintering of the fungus.

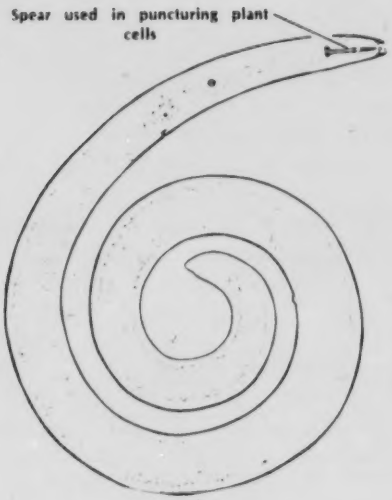


Typical growth of powdery mildew on a leaf showing formation of spores (see arrow)

Mildews are caused by fungi that infect cells on the leaf surface. The powdery mildew fungus infects ornamentals and many vegetables. Loss of plant vigor is noted on infected ornamentals, and plant death usually results on vegetables.

Downy mildew is a completely different disease from powdery mildew. It affects many types of plants, but the most common are squash, cantaloupes and cucumbers. Yet another type of downy mildew attacks sorghum and corn. Primary infection takes place on the root system below the soil. Infected plants assume a striped appearance and will be sterile. Since the plant will not produce grain, it is actually a weed.

Mosaics are caused by viruses. Maize dwarf mosaic on grain sorghum produces a mottling in the upper leaves. This virus is transmitted by aphids from infected Johnsongrass to grain sorghum and corn. Once a plant is infected, it will remain so for life. Johnsongrass shows the same symptoms as those on corn or grain sorghum. If Johnsongrass is controlled in and around the field, early infection can be reduced.




General shape of a nematode

Nematodes are microscopic roundworms that live in the soil. Certain types are parasitic and feed on living plants. These cause plant stunting along with uneven growth and chlorotic foliage.

The most common plant parasitic nematode is the root-knot-nematode which causes knots or galls to form on the roots. This places a severe restriction on the plant's ability to absorb water and nutrients. Plants may even die when placed under drought stress.

Plant diseases and nematodes can be controlled by efficiently using chemical and cultural control recommendations. In some cases, they can be controlled by using resistant varieties and in other cases, one must rely on chemicals. When chemicals are needed, use them at suggested intervals to get the highest level of control possible.

When planning disease control programs keep the following concepts in mind:

- Disease-causing organisms are microscopic in size.
- Recognizable symptoms are produced on the plant.
- All plant disease-causing organisms can be controlled to a degree where damage will be reduced.

Seedling disease of cotton

Disease damage is prevented more easily than controlled. Effective prevention methods include using cultural practices such as crop rotation with unrelated crops, planting disease-resistant varieties and utilizing specific land preparation practices. Chemical control often is needed when cultural practices are ineffective alone.

Disease control chemicals are classified variously as fungicides, bactericides or nematicides. These names indicate the type of diseases they will control. Many chemical products exist under each classification. Extension recommendations serve as a guide in suggesting a variety of products that will control a specific disease condition. Product labels explain how the product can be used for effective control.

## Weed control

Weeds conflict with man's interests in many ways.

Weeds and brush are nuisances, causing extra mowings on roadsides and obstructing water flow in drainage facilities. Weeds may harbor insects and diseases which attack adjoining crops.

Weed seeds also lower grain quality. Dayflower seeds in rice are one example. Poison ivy causes skin irritation and stinging nettle causes skin rash. These weeds are a nuisance in parks, recreational areas and some lawns.

The cool season weeds, annual bluegrass, clovers and lawn burweed reduce turf quality in home lawns and on golf courses. Weeds reduce the yield of valuable crops by competing for moisture, nutrients and light. For example, pigweed, Texas panicum and morningglory may compete with corn.

Weeds can be identified from the growing plants and their seeds. Crabgrass, morningglory, pigweed and Johnsongrass, which are warm season weeds, are found in many crops. Crabgrass, morningglory and pigweed are annuals; Johnsongrass is a perennial. The season and duration of growth determine the time and frequency of chemical treatment for control.

*Annual* weeds complete their life cycle within 1 year. They may be winter annuals germinating in the fall, overwintering and completing their life cycle the next summer. An example is henbit. Summer annuals germinate in the spring and complete their life cycle by fall. Examples are goosegrass and barnyardgrass.

*Biennials* complete their life cycle within 2 years. The plant forms basal leaves and a tap root the first year; the second year it flowers, matures and dies.

*Perenniale* are weeds that live for many years. They may be divided into simple or creeping. Dandelion is a simple perennial. Purple nutsedge is a creeping perennial, spreading by underground roots as well as by seeds. Others are silverleaf nightshade and field bindweed.

Weed control methods include biological, mechanical, cultural and chemical. Animals, birds and insects sometimes are used for biological control; however, few weeds are controlled biologically. One example of biological control is a flea beetle feeding on alligator weed that has invaded drainage and irrigation ditches on the Texas Coastal Plains. Handpulling is the oldest weed control method. Other mechanical methods are hoeing, mowing, cultivating and other tillage operations. Crop rotation, competition and good management are cultural weed control methods. A dense, vigorous cotton crop can compete against most weeds.

Purple nutsedge

Chemical weed control has grown in use and popularity since the advent of 2,4-D in the 1940's. About 140 herbicides are now used for weed control. Factors affecting chemical weed control include plants, soil and climate.

A seedling grass plant has its growing point below the soil surface. Control is more difficult when the growing point is protected in this manner. Creeping perennial grasses, such as Johnsongrass, have protected buds below the soil surface.

Seedling broadleaf weeds, in contrast to grass weeds, have an exposed growing point at the top of the young plant. Broadleaf weeds have growing points in the leaf axils of the larger plant. Herbicides are absorbed and move quickly to the growing points for control. Perennial broadleaf weeds have many buds on creeping roots. Herbicide translocation into the creeping roots must occur for control.

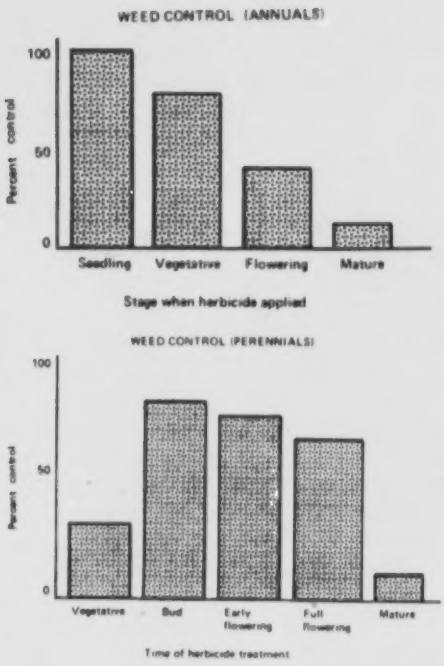
Bulbs and tubers have vegetative parts capable of sending up new plant growth, such as wild onion and nutsedge.

The seedling stage is the same for annual, biennial and perennial weeds. They all start from seed. Less energy is required for weed control at the seedling stage than any other stage. Perennial and biennial seedlings must come from seeds and not from underground structures. This is true whether the energy is mechanical, chemical or cultural.

During the vegetative growth stage, the weed is using energy for growth. Control at this stage is still feasible but more difficult than at the seedling stage. During the flowering stage, most of the weed's energy goes into the seeds. At this stage, control for grass and broadleaf annual weeds is only feasible to prevent weed seed maturity. Most weed competition is exerted against the desired plant or crop.

Almost 100 percent control is obtained at the seedling stage. At the vegetative stage, control drops to approximately 75 percent and at the flowering stage, it goes below 40 percent. Little control is obtained if herbicides are applied at the mature stage.

Part of the energy used to produce stems and leaves for the vegetative growth stage of perennials is derived from the energy stored in the underground root system. Other energy comes from the plant leaves. At a certain point




most of the energy of perennial weeds goes into producing flowers and seeds.

Long-term control of perennial weeds treated at the vegetative stage is poor. Control at the early flowering stage almost equals the control at the bud stage, and control is very poor at the mature stage. Apply herbicides to perennial weeds at the bud stage for effective long-term control unless the herbicide is labeled differently.

Herbicides applied to weed foliage must penetrate the leaf surface to give control. Wax and cuticle thickness influences the entrance of a herbicide into a leaf. Spray is in good contact on leaves with thin cuticle and wax, but spray will bead up on a leaf with thick cuticle and wax.

A weed leaf with surface hair is more difficult to wet because the spray droplets stand up on the hair and do not touch the leaf surface. Surfactants used in herbicide sprays reduce surface tension and increase the spreading of the spray.

Herbicides may collect on the soil surface from treatment on weed foliage. Other herbicides are applied to the soil surface preemergence. Soil type and its influence upon herbicide movement are important considerations. Two important soil factors are texture (sand, silt and clay content) and organic matter.

Few herbicides at low rates are used in sandy soil because sand particles and the herbicide do not attract. The herbicide moves deeper into the soil profile under rainfall. The herbicide and the clay particle attract. Thus, it is tied up on the clay particle and will not continue moving through the soil profile under rainfall.

The herbicide moving through the soil is tied up by organic matter and remains near the soil surface. Organic matter and water, sodium, calcium and ammonia also have strong attraction. Higher herbicide rates are used in soil with clay and organic matter because the herbicide tied up on the soil is not readily available for weed control.

Water is used to activate soil-applied herbicides. An application is made and either irrigation or rain leaches the herbicide into the soil surface. Soil incorporation by rototilling is another herbicide activation method.

Temperature and humidity are climatic factors influencing herbicidal activity.

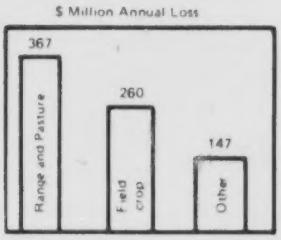
Temperature influences the timing of results from some herbicide treatments. At 35°F about 60 days are required for 100 percent control; whereas, at 65°F 2 weeks are required and at 95°F only a few days are necessary. The overall result of complete weed control is the same. It is merely the number of days required to see the full effect.

As the humidity increases from 0 to 100 percent, uptake of a herbicide by a weed leaf increased from low to high.

In summary, the steps in weed control are as follows:

. Be sure of weed identification.
. Determine its season of growth.
. Know the crop or location infested.
. Use a selective herbicide for the weed.
. Time the amount of herbicide for control.

Brush control




Brush infests 88 million acres of Texas grassland, reducing potential livestock production by 50 percent and causing an annual loss of more than $367 million. Proper control methods are necessary to restore the natural rangeland resource.

Wildlife such as buffalo, deer, quail and other game animals and fish use rangeland natural resources, and plans must be made to improve or maintain their habitat. Livestock, game animals and recreation can be planned so the long term brush and weed control program will benefit each and produce the greatest return from natural resources.

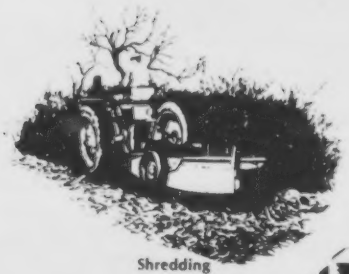
Brush species common to Texas vary with the state's geographic area. These include the common persimmon in East Texas, mesquite in the Rolling Plains, creosotebush in far West Texas and the mixed brush species of South Texas which include blackbrush, whitebrush and twisted acacia.

Brush reduces use of the rangeland resource. Areas that were once open savannahs of oaks and grasses will become dense underbrush, limiting stocking rates and reducing wildlife habitat if overgrazed.

As with insects, plant diseases, weeds and vertebrate pests, correct identification of brush species is an essential element in developing control measures. In an area that has had too much brush removed for ideal wildlife cover, control may be obtained in several ways including:

*Biological* - Grazing goats to control oak sprouts is practical and profitable.

Root plowing



Shredding

Bulldozing

Chaining

*Mechanical* - Chaining, root plowing, tree grubbing, etc.

*Chemical* - Use of herbicides.

Knowledge of the biology and physiology of the brush species is helpful. For example, most woody plants have buds that grow when tops are removed. Thus, the hand axe, the oldest control method, is also the least effective.

Mesquite has a ring of buds around the root 4 to 8 inches below the soil surface which sprout when the top is killed. Many woody plants are root sprouters such as Texas persimmon, lotebush and macartney rose.

Chemical control is accomplished with herbicides. One can choose between liquid and pelleted formulations to control many brush species. There is also a choice of application method. Basal pour of kerosene or diesel oil is the oldest and one of the most effective chemical control methods of mesquite and huisache. To be effective, the soil must be dry so the oil can penetrate to the bud zone.

Trunk basal application of some herbicides can be used anytime except when plants are leafing out or going dormant. Success of the treatment is best when the soil is dry and the solution can penetrate the soil surface.

Mesquite with ring of buds

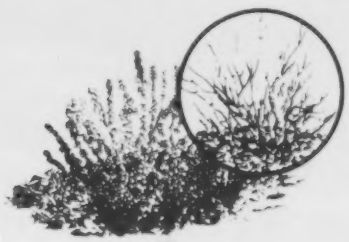
Spraying on trunk base

Basal pouring of oil

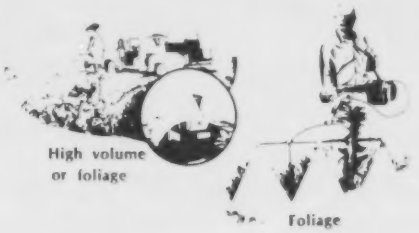
Spraying cut stump

Cut surface methods of stump and frill can be used successfully anytime during the year. Apply herbicide solution with a sprayer or tree injector in the undiluted form. The tree injector method is ideal for timber stand improvement.

Pelleted formulations of herbicides are applied best when plants are dormant. Rainfall is required to move the herbicide into the soil and in contact with the plant root area so the chemical can be absorbed by the roots and translocated throughout the tree system.



Soil surface




Apply foliage-wetting spray after plant leaves are developed fully in the spring. Thoroughly cover plant leaves and stems with herbicidal solution for satisfactory plant kill. This method requires high volumes of up to 500 gallons per acre.

Spray herbaceous weeds when they are young and less than 6 inches tall.

Some weeds such as the threadleaf groundsel are toxic to grazing animals. These plants are controlled best with chemicals in the spring when young or in the fall after new growth following rains. On the other hand, spray poisonous loco weeds in late winter before they bloom.

It is important to remember that livestock sometimes graze poisonous plants following a herbicide application. Keep livestock out of sprayed areas until all plants are dead and forage plants have added growth.

High-producing, native forage plants reestablish rapidly following herbicidal control of broadleaf weeds. Properly timed chemical weed control allows bird food-producing weeds to grow, which is an important environmental consideration.

Physical spray drift from the target area is hazardous during herbicide application on grasslands or croplands. Drift can be reduced if applications

are made when wind velocity is under 10 mph, using lower sprayer pressure, and when air temperature is less than 95°F, using drift control additives that increase droplet size when added to the herbicide solution. Drift control additives also serve as wetting agents.

Infestation of woody and herbaceous plants occurs following initial control. Follow a long term brush and weed control program with maintenance control of reinfesting plants for a properly balanced plant community and best use of all natural resources.

Brush and weed control using proper control methods combined with good grazing management will maintain the natural resources for livestock production, wildlife habitat and recreation.

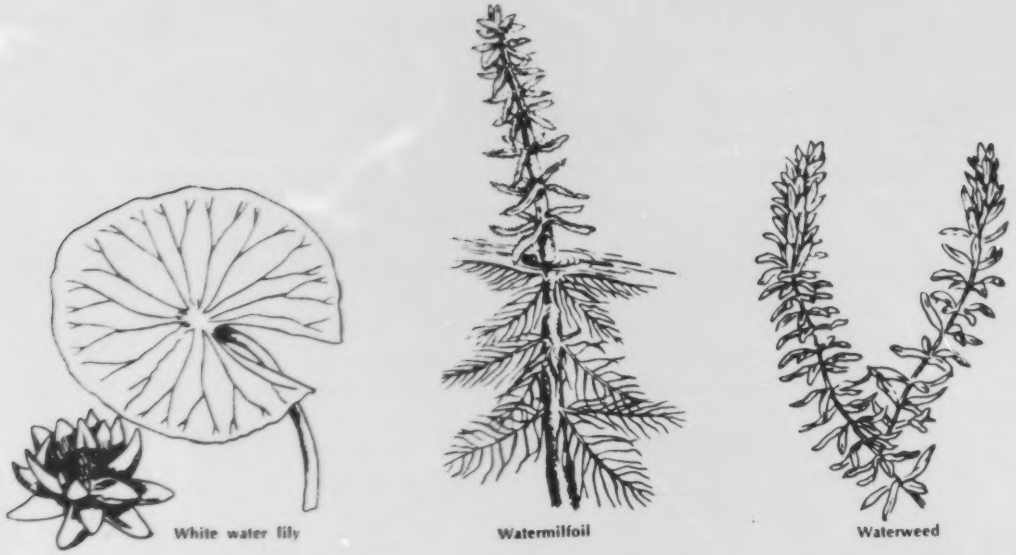
Aquatic vegetation control

Identification is the most important requirement for successful aquatic vegetation control. Most control methods are aimed at specific weeds or groups of weeds. Emersed aquatic plants grow up out of the water or along the edges of ponds or lakes. These include cattails, bulrushes and arrowheads.

Submersed aquatic plants grow under the water although they may have leaves that come to the surface of the water. Pondweeds, bushy pondweeds, coontail and milfoil are in this category. Leaves or the entire plant in the floating plant category rest on the surface of the water. Examples of these are duckweed, water hyacinth and water lilies.

Bushy pondweed

Water hyacinth




The fourth type of weed, and one that poses many problems in Texas, is the algaes. These are weeds without true stems, leaves or vascular systems. Examples are the phytoplankton which gives the green color to water, the filamentous algae or pond scum and the branched or higher algae such as muskgrass. Most of these plants are troublesome in some situations and beneficial in others, depending upon their abundance and how the water is used.

The most important factor in controlling or preventing aquatic weeds is proper design and construction of ponds. Shallow water at the edge of ponds provides ideal habitat for weeds such as cattail and also is conducive to algae growth. Banks should be sloped allowing a minimum of water less than 3 feet deep. Sometimes it may be necessary to use mechanical control to rid the pond of submersed weeds. Disposing of mechanically harvested weeds is usually a problem. Most mechanical control methods fragment the plants which may encourage spreading since weeds will reproduce from fragments. Mechanical control is usually slower and much more costly than chemical control.

Another method of mechanical control is to drain and dry the pond. The season of the year and the species of plants present may determine whether this method will be useful in a particular situation. Also, you must consider the existing fish and their normal spawning time before contemplating draining and drying.

Fertilizer use is usually considered mechanical control. Fertilization stimulates growth of microscopic algae which in turn shades the bottom and prevents or reduces growth of submersed weeds. Ponds with a high rate of water exchange usually do not respond well to fertilization.

Biological controls also may be used. These may include herbivorous fishes such as the tilapia. An introduced species, tilapia will not survive

winter temperatures in most parts of Texas unless there is a hot water discharge. Other biological controls include insects, but very few have proven effective even though many insects currently are being studied.

Chemicals used in aquatic weed control are available in several formulations. These include liquid and granular formulations, emulsions and invert sprays. Emulsions are used for non-water soluble herbicides. Granular herbicides are used for spot treatment when it is necessary to get the herbicide to the root of the plant and build up a herbicide concentration in a localized area. Liquid herbicides are used when it is necessary for even chemical dispersion throughout the water to bathe the entire plant in the herbicide solution.

Application techniques also are important in treating aquatic vegetation. For those plants which grow to the water's surface, a surface treatment is adequate. For submersed plants, a total water treatment normally is required. Whenever a total water treatment is contemplated, consider the toxicity of the chemical to fish or other aquatic organisms. Another method involves treating soil in the drained pond or lake. This is quite effective and requires less chemical.

Weed control in flowing waters is very difficult. Herbicides applied may flow out of the pond and into streams causing possible damage to crops irrigated with the water. Some chemicals also may cause a problem with domestic, industrial or recreational waters. To preclude damage, it is best to read the label carefully and investigate the possible use of the water after it leaves the treatment area. Therefore, aquatic vegetation control involves identifying the weed and using only those chemicals which are cleared for use on particular weed species.

Incorrect application of herbicides, fish toxicants or insecticides to water may involve serious hazards to man, fish, desirable plant life, wildlife, adjacent crops and livestock.

Carefully check restrictions on each chemical before using it. Some chemicals cannot be used in ponds where fish are to be grown for food. Other chemicals cannot be used when the water is intended for human consumption. Many chemicals cannot be used in water intended for subsequent irrigation. Therefore, control of aquatic vegetation presents special problems because waters often have multiple uses and herbicides will not always remain where applied.

Excessive or inappropriate chemical applications can cause damage from direct toxicity or suffocation from an excessive or rapid kill of plant materials which depletes the oxygen supply. Bacterial contamination is a secondary problem resulting from dead fish decay which contaminates downstream water supplies. Water may not be suitable for irrigation or human consumption, and it may be necessary to restrict livestock from using the water.

## Wildlife damage control

The objective of wildlife damage control is to alleviate a problem, *not* destroy wildlife. Many problems of wildlife damage may be solved by applying preventive control such as sanitation, and this should be the primary goal. However, there will always be problems and situations where reduction of animal numbers is necessary.

Wildlife is a public-owned resource protected by numerous federal and state laws. Before any wildlife damage control program is begun, determine the legal status of the animal since the laws will influence the selection of techniques to be used. Texas Parks and Wildlife Department and U.S. Fish and Wildlife Service are the state and federal regulatory agencies to contact about laws related to wildlife protection.

Man experiences problems with naturally existing wildlife populations because man and wildlife depend upon the same resources. Since wildlife does not recognize human ownership of a resource, the possibility for conflict will always exist. For example, cormorants catch and eat farm-reared fish just as readily as they catch and eat wild ones.

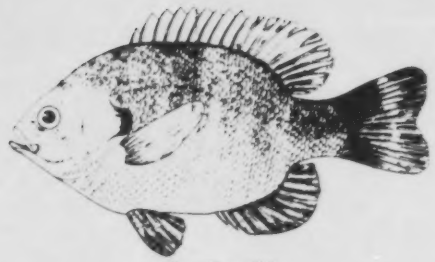
Beaver dams flood bottom lands

In any given situation, one or more wildlife species including mammals, birds, reptiles, amphibians or fish may conflict with man's interest. Under favorable conditions, some wildlife populations may increase to problem levels. Gopher damage to seedling trees following timber harvest is possible because of increased gopher numbers. Problems develop because gophers, while feeding on grass and weed roots, also eat roots of newly planted tree seedlings.

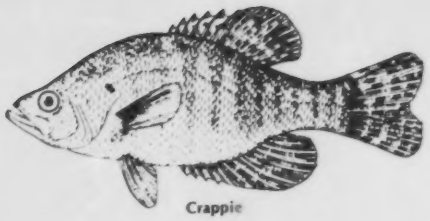
Nutria, a large rodent, is a valuable fur resource in coastal marshes. However, in fresh water impoundments, rice fields or farm ponds, its denning activities damage levies and dams. Rodents are most frequently associated with problems because there are many species which are highly productive and widespread.

Some fish species are considered pests in certain situations. These fish compete with the desirable fish for food, space or other necessities of life. Another pest might be those fish that affect the crop you have in the pond or ones that feed upon the more desirable fish. Controlling pest fish varies with every situation, species and intended use for the desirable fish. Though some fish may be pests at certain times, they may also be protected game fish, such as largemouth bass. Non chemical control includes draining ponds or using physical barriers such as traps, nets or barrier dams. Carefully investigate chemical control so that desirable species are not affected.

Largemouth black bass



Bluegill sunfish



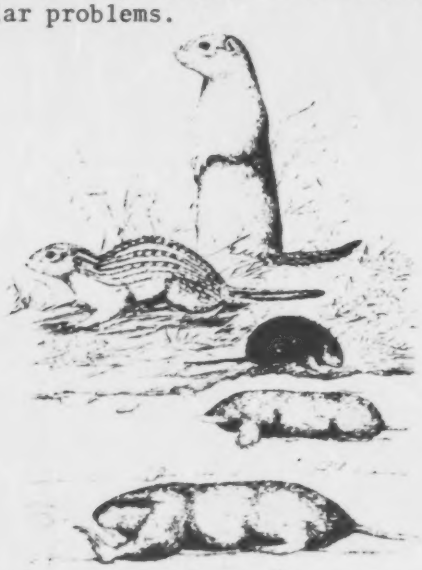
Crappie

Chemicals are available which are selective against certain species of fish, and other chemicals are available which remove all fish from a particular body of water. Just as in applying herbicides or insecticides to a particular body of water, use of fish toxicants should be planned and monitored carefully to avoid escape of the chemical which might harm other streams or lakes in the vicinity.

Techniques of wildlife damage control might be categorized under three broad approaches: environmental modifications, repellents and population reduction.

Many pest control techniques are needed for handling wildlife damage because each situation presents some unique aspects. Such variables as species causing damage, crop to be protected, season and duration of damage, legal status of wildlife, biological characteristics of the nuisance animal and species behavior influence the choice of a technique.

Presence of an animal capable of causing damage does not always dictate control. It is not easy to determine when control is necessary. The control level must be balanced with cost, effort and the value of the goods preserved. While very obvious at times, objective data are difficult to obtain in particular problems.



Rodents frequently causing pest situations

Armadillo

Obvious animals may not be causing a problem. It is important to determine first if there is damage, and, if so, to examine the damage closely to identify the species causing the damage. For example, avocets frequently are seen in wet fields along the coast. They

Animals commonly found near man

and other wading birds probe the mud of newly flooded rice fields. However, many consume insects, crustaceans, brine shrimp and other small aquatic life, not seeds such as rice.

Biological characteristics differ between groups of animals; although, in some cases their damage is similar. The first step in solving a wildlife damage problem is identifying the species involved since any one technique is not appropriate for all species. For example, controlling beaver damage requires traps while a pesticide may be more appropriate for nutria control.

Species causing problems must be identified from circumstantial evidence at the site of damage. Since most mammals are active at night, their damage may become extensive before the animals themselves are noticed. Tracks are one distinguishing characteristic for an animal. By using all evidence, including rubs, hair, tooth marks, fecal matter, feathers and tracks, a careful observer can make an accurate identification.

Dark crescent-shaped markings near the rafters indicate the presence of roof rats. Roof rats move high in buildings rather than along or under the floor like Norway rats. A rodenticide or other control materials must be placed correctly for the animals concerned or it will not be effective.

All wildlife requires food, cover, water and space, and the place where the animal lives must supply these needs. Environmental control is making the environment inhospitable by removing one of these essentials. Generally this produces the most lasting effect. Since considerable time may be required for environmental manipulation, anticipate problem situations to avoid conflict.

Duration and season of the damage impact are important in determining the degree of control needed. Protecting the tree seedling from deer browsing may be necessary for 6 months during each year for a decade, while protecting corn from blackbirds is only needed for 2 or 3 weeks in the spring. Different techniques are dictated by the time interval. A fence may be necessary with deer while a repellent would be appropriate with blackbirds.

Repellents are used to change animal behavior. They can be applied rapidly after a damage situation is identified; however, results are highly variable depending upon the skill of the applicator. It is important to begin control prodecures as soon as possible, even before damage begins. After feeding habits are established firmly the animals are difficult to displace.

Repellents produce an adverse response in animals through one or more of their senses. They may be categorized according to the sense which is affected: hearing, sight, smell, taste or touch.

Taste repellents require that animals consume a portion of the protected crop to taste the repellent. Many chemicals taste bad and repel animals, but they may leave a residue on the crop that is not easily removed from edible plant parts.

Seedling damage may be difficult to prevent with taste repellents. The taste repellency of a chemical differs between species of animals so the correct repellent must be used to achieve positive results. Taste repellents are difficult to use on rapidly growing plants because of the animal's habit of feeding on the newest growth, perhaps not consuming the chemical.

Repellents to the sense of smell have been used a long time. Foul smelling concoctions have been used to frighten everything from deer to evil spirits. Volatile materials usually have a short life, necessitating frequent applications. Susceptibility varies greatly between animals.

Of newer origin are the physiological repellents. This type of repellent has been tested to protect sprouting corn from pheasants, grackles and crows. These chemicals, when eaten, act through the nervous system causing an unpleasant experience for the animal. With solitary animals, each individual must learn what to avoid. Therefore, some damage will occur during the learning period.

In highly social animals, such as blackbirds, distress in some members of the group is communicated to the entire group, and the group responds. A different approach may be used. The physiological repellent may be a toxic material given in lethal doses, but only a very small fraction of the flock receives the treated bait with the remainder receiving untreated bait. Thus, a few animals are sacrificed to drive away the remainder of the group.

The third approach in reducing wildlife damage is to directly reduce the population of offending animals. This usually means using lethal techniques. Vertebrate pesticides are seldom selective; therefore, the applicator must limit effects of use to target animals through knowledge of the animals' behavior and feeding habits, such as use of the gopher mound building machine in gopher control.

Red-winged blackbird

Brown-headed cowbird

Starling

A method used to reduce an animal population in a particular situation usually is determined by its legality, efficiency, economy and ability to affect only the target animals.

Consider population control in three levels each with somewhat different objectives: selective removal of individuals, general population reduction and supression and population extermination.

Selective removal of individuals causing damage has the least environmental impact. However, it requires a good knowledge of the species' life history and behavior and/or a highly selective technique. It is used where considerable damage is caused by a few animals, such as a coyote in a turkey yard. Being selective usually means expending considerable effort per animal removed.

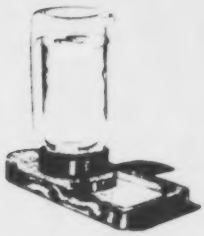
Lethal techniques must be applied diligently to achieve any significant reduction in species with high reproductive potential or only a cropping of the surplus will occur. In fact, removing surplus animals may stimulate greater reproduction and compound the problem. This compensatory mechanism common to many vertebrate species necessitates controlling reproduction.

Populations also may be reduced or controlled by suppressing reproduction chemically. Chemosterilents are presently available for pigeon control. Though the technique is too new to have widespread application, it offers a desirable option to destroying existing animals.

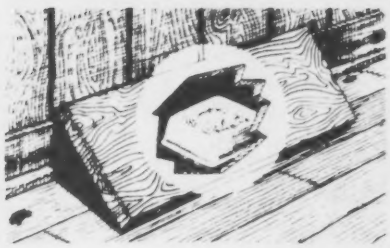
Extermination or eradication of a group of animals over a large area is very seldom a worthwhile or achievable objective. However, eradication in some instances, such as gophers in a field, is appropriate. Commensal or domestic rodents are perhaps the most commonly occurring examples.

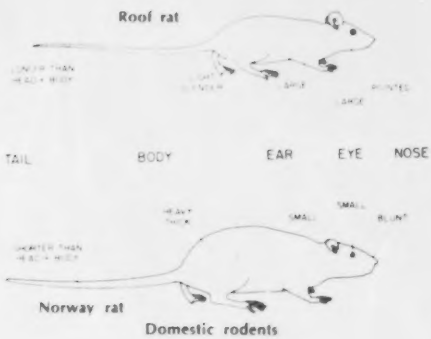
Pesticides for vertebrates may be received via a number of ways: ingestion (eaten), absorption (through the skin) and inhalation (breathing). This offers several possible means of reaching the target species and excluding others.

Pesticides which are eaten usually are presented with a bait or water, making bait selection important. Season of the year, availability of other foods and acceptability to target and nontarget animals are considerations in



Bait and
water poisoning






Domestic rodents

Inhaled fumigants

choosing a bait. It must be highly acceptable, or bait shyness may develop. The pesticide must be capable of being hidden or must be acceptable to the animals involved. Target species may be repelled by odor or taste of the chemical.

Pesticides acquired by absorption are limited in use because of hazards to other species or because of difficulty in presenting the chemical to the target animal. Tracking powder used with domestic rodents is probably the most common example.

Pesticides which are inhaled also are rather specialized. Fumigants usually are limited to use with animals in close confinement, such as burrows or buildings. They are effective in treating Norway rat burrows.

Some pesticides present hazards of secondary poisoning. Therefore, carcasses of treated animals must be collected and destroyed. Control of some animals such as prairie dogs may expose the applicator and others in the vicinity to external parasites which could be disease carriers. Treatment to kill parasites before vertebrate control is advisable.

Principles of wildlife damage control might be summarized by:

. Recognizing damage patterns and responsible species

. Knowing the characteristics and life habits of the species

. Knowing available control measures

. Knowing regulations

. Evaluating risks versus benefits

## ENVIRONMENTAL CONSIDERATIONS

The benefit to man's health, comfort and general well-being from the use of chemical compounds to control pests including animals, plants and micro-organisms include:

- Use in food, feed and fiber production including protection in storing, processing, etc.
- Protection of health to include disease, vector and nuisance pest control
- Use in commercial-industrial situations including utility and highway right of ways, oil tank farm, industrial sites and structural pests
- Use in improving the aesthetic environment on such things as shade trees, ornamentals, golf courses, parks and home lawns
- Use in environmental management where environmental quality and ecological considerations are the overriding basis for pesticide use
- Reduction in power and labor requirements to lower fuel costs and maintenance and replacement costs
- Conservation of moisture
- Reduction of allergy sources
- Reduction of fire hazard

The environment is dynamic, constantly receiving and recycling energy and matter and providing a support system for all living things. Man's alteration of local environments may result in concentrations of natural and synthetic substances in excess of the environment's capacity to utilize, alter and absorb them. Less evident but sometimes equally serious effects have been determined to extend beyond the local boundaries as a result of distribution and cycling of the substances through the air, water and soil environments. In recognition of this man's activities are now evaluated in terms of environmental impact, benefit-risk and social acceptance. Most writings, symposiums, conferences and workshops on environment the past 10 to 15 years have included at least a reference to pesticides and the environment. These concerns have developed into federal law and regulations in which "unreasonable adverse effects on the environment" are criteria by which pesticide uses are classified.

Use of pesticides results in their introduction into the environment or in the case of agricultural use into the field environment where numerous forms of plant and animal life exist. For the most part, pesticides break down and do not persist in the environment. Thus, effects in most cases are limited to the site of application. Even so effects are not selective; they are at least of limited selectivity within the area or site of application. The pesticide may move from the application site by air, soil and water distribution and may also move through organisms by direct exposure or exposure through the food they consume, such as other organisms. This is sometimes called a food chain; if residues are concentrated, the process is called a biological magnification or biomagnification. Environmental effects of pesticides may include:

- Development of resistance
- Release of secondary pests

. Reduction of beneficial populations
. Reduction of pollinators
. Contamination of soil, water and air
. Effects on wildlife and fish populations
. Residues in domestic animals
. Residues in humans

Resistance can and has resulted from long-term exposure of populations of high reproductive capacity such as insects and fish. This exposure is sometimes called selection pressure. Certain organisms within a population may have a greater ability to survive the effect of a pesticide. Those surviving constitute the breeding population producing generations that may share the ability to resist a pesticide. Succeeding generations following continued selection pressure tend to contain larger and larger populations of resistant individuals. Resistance is a well documented phenomena in insects and has been documented in fish, frogs and mammals. More than 225 species of insects and mites have been reported resistant in at least part of their range of distribution. Resistance also has been reported in pests of man and animals including mosquitoes, flies, ticks and bedbugs. Resistant animals also can have the potential of compounding the problems of biological magnification through food chains. Another compounding aspect of resistance involves a strain of animals that becomes resistant to other related insecticides to which the population has not been exposed. Resistance poses many problems, not the least of which is the loss of efficiency of pest control.

Reducing beneficial species is another possible environmental impact of pesticide use. Insect pest-parasite and predator relationships in the field environment, sometimes called the agroecosystem, can be disrupted. Treatment may kill many insect predators and parasites that in their natural and undisturbed state have an influence on the population of the target pest as well as other potential pest species. Usually the selection pressure resulting in resistant pest species does not cause resistant beneficials or natural enemies. A number of reasons have been suggested for this difference, one of which is that a pesticide, although possibly having no direct effect on the beneficials, may reduce their number by limiting or eliminating the host upon which its survival depends.

Weeds become major pests when competition from other weeds is eliminated or when nonsusceptible species previously excluded by competition grow in their place or the area becomes occupied by more opportunistic weed species.

Reducing "beneficial" or natural enemies may cause a resurgence of the pest or the release of secondary pests following control attempts using pesticides. Surviving individuals of the target population may resurge quickly as a result of release from pesticide pressure due to resistance and release from natural control. Species not normally a pest problem may be released by disrupting natural factors that hold the population in check.

The production of certain crops, such as alfalfa seeds and cantaloupes, is dependent upon the presence of pollinators, including honey, leafcutter and bumble bees. Insect pollination of crops has become an important concern. In all these instances, the environmental effect of pesticides can be reduced by proper selection, use and timing.

In directing pesticides to a target, they also reach air, soil, and water directly or indirectly. In some cases application is direct to soil or water, and in most cases application is made through the air surrounding the pest or pest habitat. In other instances pesticides added to the environment are indirect through drift or crop residues. Pesticides may, if they persist for a sufficient period, cycle through the physical environment by atmospheric transport, rainfall and biological systems, such as food chains.

Effects of pesticides in the environment of birds and mammals as a component of both the aquatic and terrestrial environment have been identified as problems. Generally, results of a toxic pollutant in the environment are expressed in carnivorous groups (flesh eaters) rather than the herbivore (plant eaters). Long-term exposure problems include, as with aquatic species, effects in reproduction, behavior and resistance. Most of the effects are related to persistant toxic materials. The food chain concentration is directly related to persistance. Delayed mortality and reproductive effects also relate to this characteristic.

An awareness of the potential of environmental harm illustrates the need for using pesticides in a manner consistent with minimal adverse environmental effect. This is characterized by efficient use, when needed, and the skill of the applicator in directing the pesticide to the target in accordance with all label directions and due consideration of local environmental situations.

## REVIEW QUESTIONS

### ENVIRONMENTAL CONSIDERATIONS

1. Exposure of organisms to pesticides through the food they consume is sometimes called a food chain and if residues of the pesticides are concentrated in the organisms, the process is called

   a) compounding
   b) biological magnification
   c) accumulation

2. Selection pressures through use of pesticides may affect populations of organisms of high reproductive capacity resulting in

   a) decreased reproductive capacity
   b) development of resistance within the population
   c) loss of mobility

3. Reducing "beneficial" insect and other arthropod populations may result in

   a) a stable pest population
   b) the release of secondary pests
   c) elimination of pest species

4. Generally, results of a toxic pollutant in the environment are expressed in

   a) herbivores (plant eaters)
   b) carnivorous groups (flesh eaters)

5. Pesticides may move from the site of application by

   a) air
   b) soil
   c) water
   d) all of the above

# FIELD CROP PEST CONTROL - INSECTS

Texas produces crops on approximately 30,650,000 acres. Of this total, field crops are produced on about 25,500,000 acres. Because many of the major field crops such as cotton, grain sorghum, small grains, corn, several forage crops, peanuts and soybeans account for most of the planted acres, the field crops section deals with insect control for these specific crops.

The following review is divided into sections dealing with each of the major crops. Because of the large number and variety of insects and mites that inhabit cropping systems, primary attention is focused on key or economically damaging insect pests. Although mites are not insects, they are lumped into the insect category for this discussion. Identification, damage symptoms, field scouting procedures to assess damage and proper timing of insecticide application based on established economic thresholds of the major key insect pests are stressed. Key pests usually cause economic damage each year and require insecticidal control on a yearly basis. Recognition and value of beneficial insects are stressed throughout the discussion along with certain cultural controls. Pests that may cause occasional damage are reviewed briefly.

For more detailed information on the identification, life cycle and control of insect pests in field crops, refer to specific publications mentioned in the text. These publications are available from the Texas Agricultural Extension Service.

## Cotton Insects

Precise timing and execution of each production operation is extremely important in reducing insect injury and maximizing profits. In planning an insect control program, the cotton producer and the pesticide applicator should consider effective use of both natural and cultural control. Major factors to consider include insecticide resistance, importance of protecting natural enemies of cotton insects, resurgence of primary pests and increased numbers of secondary pests following insecticide applications, environmental contamination with pesticides and increasing restrictions on pesticide use. Therefore, insecticides should be applied only when necessary, as determined by frequent field inspections, to prevent economic losses from damaging pests. *This approach to cotton pest management is preferred over other alternatives available to cotton producers.*

Cotton pests typically are grouped into early, mid- and late-season pests based upon when they occur in the seasonal development of the plant.

Early season pests, such as thrips, cotton fleahopper and overwintered boll weevil, attack cotton at various times from the seedling stage through the appearance of the first 1/3-grown square stage.

Thrips may attack cotton from the time it emerges in the spring until squaring begins.

Adult thrips are minute, slender, yellowish insects about 1/15 of an inch in length.

Thrips damage young cotton by rasping plant tissues with their mouthparts and sucking plant fluids. Cotton leaves damaged by thrips take on a silver color and wilt or become deformed and turn brown to black. Heavy infestations may reduce stands, stunt growth and delay maturity.

Cotton should be inspected routinely when it comes to a stand. Examine cotton in several locations in the field once cotton emerges. If thrips are present and damage of the first true leaf buds between the cotyledons is observed, treat at once. Based on field inspection, apply a second insecticide application 7 days later if damage persists.

Cotton is vulnerable to thrips attack in years of cool-wet springs. As temperatures rise, the plant grows rapidly and may tolerate higher thrips populations without sustaining damage.

The cotton fleahopper adult is 1/7 of an inch long. They are pale green, have dark spots on the body and four dark spots near the wing tips. The immature nymph is white and translucent shortly after hatching from the egg; they become pale green after feeding.

The cotton fleahopper damages the small, pin-head-sized squares by sucking sap. Sap depletion causes the small squares to dry-up, turn black and drop from the plant.

As cotton begins squaring, about 35 to 40 days after plant emergence, the first 3 weeks of squaring is the most critical time for cotton fleahopper damage. When cotton begins blooming, 55 to 60 days after emergence, it is considered past the cotton fleahopper susceptible stage, where normal fruiting has occurred before this developmental stage.

To sample a field for cotton fleahoppers, examine the terminal portion of 25 cotton plants at random in four to five locations in the field.

Base all insecticide treatments on 15 to 25 percent damaged pin-head sized squares as well as fleahopper numbers. During the first 3 weeks of squaring, 25 to 50 cotton fleahoppers (nymphs and adults) per 100 terminals may cause damage.

When the boll weevil moves from overwintering quarters into cotton in the spring, control may be necessary. Control of overwintered boll weevils will delay subsequent generations and allow fruiting to proceed with reduced boll weevil damage. Not all fields will be infested with overwintered weevils; therefore, base any decision to apply an insecticide on the field history of boll weevil attack, the nearness of the field to favorable overwintering areas such as creek bottoms, shelter belts or other areas where broadleaf plant litter has accumulated and, if possible, the presence of boll weevil adults or feeding damage based on sampling several row feet of cotton near favorable overwintering habitat.

Overwintered boll weevil application should not be applied automatically to all fields. If a decision is made to treat based on these criteria, apply insecticides when 1/3 grown squares first occur in the field. A 1/3 grown square is approximately 1/4 inch in diameter with the bracts removed, or about the size of a standard pencil eraser. Most boll weevil adults move into

cotton at the 1/3 grown stage. A second application may be required where adult weevil movement into the field continues. And, *if necessary*, apply a third application 3 to 5 days later. All insecticide applications should cease 10 to 12 days before bloom to allow beneficial insect populations to build back up.

Midseason is considered to be the 6-week fruiting period following the appearance of first 1/3-grown squares. Late season is the remainder of the production season, during which time the bolls are matured.

Key insect pests that may damage cotton during the mid- and late-season are boll weevil, cotton boll worm and tobacco budworm.

The adult boll weevil punctures and deposits its eggs in 1/3 grown or larger squares as well as bolls. The female seals the egg puncture with a cement like fluid. As the wound heals, it produces a projection or "nipple" on the surface of the square.

The square falls from the plant in 8 to 9 days as the small grub consumes the inside of the square. The larvae are pearly white with the body slightly curved in a grub-like posture. The weevil then pupates and emerges as an adult from the fallen square or small boll.

Damage during the first 6 weeks of fruiting is indicated by the percent of squares punctured by the boll weevil. Sample the field regularly (weekly) to determine punctured square percentages.

Randomly inspect 100 1/3 grown squares, 25 at each of four sites in the field. Additional samples may be required if fields are larger than 100 acres.

If 15 to 25 percent or more of the squares sampled are damaged, begin treatment. Continue field sampling all season to determine damaged square percentages. As hard bolls form and the crop is set, much higher levels of square damage can be tolerated.

The cotton bollworm and tobacco budworm are closely related species that may damage cotton.

The egg usually is laid in the terminal leaves, but may be scattered over the plant. The egg is dome-shaped, white and ribbed. When first laid, it is white. As the embryo develops within, the egg turns tan and then black just before hatching. The larva hatches from the egg in about 3 days.

The cotton bollworm and tobacco budworm larvae vary in color--sometimes light green, pink or brownish with alternating light and dark stripes.

The larvae require about 14 days to develop and range in size from 1/16 inch to 1 ½ inch when full grown.

Cotton is vulnerable to bollworm/budworm attack from squaring through boll set growth stages.

Twice-weekly field inspections may be required to determine the larvae number and size and the amount of damage caused by feeding larvae. The larvae do most damage by feeding on squares and small to medium sized bolls.

Beneficial insects such as lacewing larvae, lady beetles, assassin bugs, pirate bugs, bug-eye bugs, syrphid fly larvae, parasitic wasps and spiders play an important role in reducing bollworm eggs and larvae. Premature insecticide applications will destroy these valuable insect allies and commonly result in additional, costly insecticide applications.

The economic threshold varies with the stage of the plant and whether the first insecticide application has been applied. If there has been no recent insecticide application, 15 to 25 percent damaged green squares represents a treatment level in prebloom cotton. If bolls are present and no recent insecticide application has been made 8 to 10 percent worm-damaged, green squares represent a damage level.

After initiation of insecticide applications, the appropriate economic thresholds change. Since insecticides destroy beneficial insects which help supress bollworm/budworm populations, the economic threshold is reduced to 4 to 5 percent worm-infested terminals *and* 5 percent damage of the green squares and small bolls.

Since chemical control of bollworms, particularly insecticide-resistant tobacco budworms, is seldom effective after worms are ½ inch long, frequent, twice-a-week field inspections may be necessary.

Before bloom randomly inspect at least 100 squares for damage and 100 plant terminals for eggs and small larvae. After bloom, inspect at least 100 squares and small bolls for damage and 100 terminals for eggs and small larvae.

For occasional pests such as aphids and spider mites which may damage young cotton by sucking plant juices or defoliators such as armyworm, cotton leafworm and cotton leaf perforator or boll damaging pink bollworms, refer to the Texas Agricultural Extension Service series L-218, L-508, L-561 and L-1219, *Suggestions for Controlling Cotton Insects*.

This series and B-933, *Cotton Insects* published by the Texas Agricultural Extension Service, will provide additional background and review material.

Grain sorghum insects

Grain sorghum is produced in nearly every major agricultural production area of Texas. Key pests of grain sorghum include sorghum midge and greenbug. Pests that may cause occasional damage at certain stages of plant development include spider mites, corn leaf aphid, yellow sugarcane aphid, corn earworm, fall armyworm and sorghum webworm.

Adult sorghum midge move from Johnsongrass and other wild hosts into grain sorghum in spring and early summer. Grain sorghum is the preferred host of the sorghum midge.

The adult midge is an orange-colored, fragile-looking gnat or fly about 1/12 inch long.

The grain sorghum is susceptible to damage *only* during the blooming and pollination period. Generally a single sorghum head, blooming from top to bottom, takes about 9 days. Most blooming and pollinating takes place the first

5 days. However, because of field variation, grain sorghum in an entire field may take up to 23 days to bloom and pollinate. The female midge deposits eggs in the developing blooms (florets). The hatching larvae or maggots feed inside the bloom and prevent seed development. Heads damaged by midge appear to be "blasted or blighted." Other causes of blast or blight such as high temperatures before booting, drought, disease and infertility resemble midge damage. The major difference, however, is the appearance of midge pupal skins on the midge-damaged head. These skins hang from the undeveloped seed.

Because grain sorghum can be damaged only by sorghum midge during blooming, *early uniform planting* is recommended strongly.

Only adult midge can be controlled with presently labeled and recommended insecticides. During the bloom period, fields should be inspected daily in several locations for the presence of adult midges. When 25 to 30 percent of the heads have begun to bloom and the number of adult midge per head averages one, an insecticide application is necessary. If adults are still active 3 to 5 days later, a second application is necessary. Three applications at 3-day intervals may be needed for heavy midge populations.

Once blooming has ceased, grain sorghum is safe from midge damage.

For additional information on the sorghum midge, consult Texas Agricultural Extension Service publications L-842 *The Sorghum Midge and Its Control* and MP-399 *Suggestions for Controlling Insects and Mites on Corn, Sorghums and Small Grains.*

The greenbug, which is not a true bug but an aphid, may damage grain sorghum. The greenbug adult and immature nymphs are often confused with other aphids that feed on or visit grain sorghum. The greenbug has a bright green body with a prominent dark green stripe down the center of its back. The corn leaf aphid, which seldom damages grain sorghum, is most often confused with the greenbug. The corn leaf aphid has a bluish-green body that sometimes appears gray in bright sunlight. It *does not* have a dark stripe down the center of its back.

Greenbugs suck plant juices with their piercing, sucking mouthparts. Toxins are injected into the plant during the feeding process. Greenbugs generally feed on the underside of the sorghum leaf causing noticeable damage to the leaf tissue. The damaged areas enlarge as the greenbugs increase. Finally, the leaf turns brown on the edges and dies. The extent of greenbug damage in grain sorghum is dependent on greenbug numbers, plant size and vigor, plant growth stage, field moisture conditions and the presence or absence of parasites and predators that effectively destroy greenbugs.

As greenbug populations are known for developing resistance to insecticides, particularly in the Texas High Plains, good judgment must be exercised before treatments are applied. Excessive, unncesssary insecticide applications enhance the likelihood of greenbugs developing resistant populations.

When to treat is related directly to plant size and presence of damage caused by greenbug colonies. Treat plants up to 6 inches in height when visible damage and greenbug colonies are observed. Allowing greenbug to continue to damage plants can result in a reduced stand.

Plants larger than 6 inches up to the boot stage can tolerate more greenbugs. Apply treatment at this stage when large numbers of greenbugs are present and before any entire grain sorghum leaves are killed.

Yield reductions during the preboot, boot, blooming and grain development stages vary with greenbug numbers, length of time greenbugs infest plants and plant condition. From boot to hard-dough apply insecticides when greenbug damage is sufficient to kill more than two normal-sized leaves.

Beneficial insects play a major role in reducing greenbug populations. Lady beetles and parasitic wasps are important greenbug natural enemies. A greenbug parasitized by a wasp ceases feeding, and turns light brown. Parasitized aphids are called "mummies."

Sorghums resistant to the sorghum greenbug are available in limited quantities. These hybrids may become the most effective means of controlling the greenbug. Producers should be aware that the primary type of resistance is tolerance, and should not expect plants to be free of greenbugs. However, resistant hybrids generally support lower greenbug populations than do susceptible hybrids. Based on previous research the economic threshold for resistant sorghums is the same as for susceptible sorghums.

At present these hybrids are only resistant to greenbugs. They do not carry resistance to other aphids, such as, the corn leaf aphid and the yellow sugarcane aphid.

Occasional pests of grain sorghum only rarely cause damage. These include corn leaf aphids which may cause stand reduction in seedling grain sorghum and spider mites that may kill leaves by sucking plant juices and cause economic damage during the bloom to soft-dough stage. Improper pesticide applications may destroy mite predators and cause mite populations to increase. Spider mites do not reduce yield after the grain sorghum has reached the hard-dough stage. The yellow sugarcane aphid is a lemon yellow with two double rows of dark tubercles down its back. This aphid also secretes a plant toxin producing a purple leaf while feeding and relatively light populations may cause economic damage to sorghum in the preboot stage. Other occasional pests such as the corn earworm rarely cause yield reduction by feeding on grain in the heads. Populations exceeding two small larvae per head in the absence of predators are considered damaging.

The sorghum webworm, another headworm, damages grain sorghum by gnawing circular holes in the grain. The mature larva, about ½ inch long, is covered with closely spaced spines and fine hairs. Its reddish tan, dark-brown body is marked with three darker lines down the back. Inspect frequently from bloom to hard-dough stage by striking the sorghum head on a white piece of paper or handkerchief. Small larvae will dislodge. Control is recommended when 10 to 25 percent of the heads are infested with five or more small larvae. For additional information on greenbugs and other aphids of sorghum consult the Texas Agricultural Extension Service publication L-819, *Greenbugs and Other Aphids of Sorghums and Small Grains*. Also MP-339, *Suggestions for Controlling Insects and Mites on Corn, Sorghums and Small Grains* should be helpful.

Small grain insects

Insect pests of small grains (barley, wheat, oats or rye) include greenbugs, spider mites and armyworms.

The greenbug can damage small grains; the damage is characterized by *yellowing* leaves as feeding takes place and toxins are injected into the leaf. During the winter, infested fields may have small yellowed spots preceding the appearance of small deadened areas. Later greenbugs in these spots may increase and spread throughout the field.

Make field inspections to determine the extent of greenbug damage. A minimum of five random locations, counting the greenbug numbers on 1 linear foot of row at each location, should be made while walking diagonally across the field. More counts may be necessary in larger fields.

The need for applying insecticides depends on the number of greenbugs present, plant size and vigor, temperature, growth stage and presence of parasites and predators. Irrigated crops can withstand larger greenbug populations.

When plants are 3 to 6 inches tall, 100 to 300 greenbugs per row foot may cause damage. When plants are 4 to 8 inches tall, 200 to 400 insects may cause damage. And finally, when small grains are 6 to 16 inches tall, 300 to 800 greenbugs per row foot may require treatment.

The number of greenbugs on plants and the other previously mentioned conditions indicate when insecticides should be applied to prevent economic loss. The appearance and extent of leaf damage in spots caused by greenbug damage also indicates a need for potential treatment. Occasionally, populations of 25 to 50 greenbugs per foot on very young, small grain plants may require treatment.

The winter grain mite may damage oats, wheat and barley in North Central and Central Texas. Mite damage is generally most severe in fields where grain has been planted continuously for several years. Crop rotation to crops other than small grains will generally control winter grain mites.

Mites range from 1/32 to 1/16 inch long. The adult has four pairs of reddish-orange legs and the body is dark brown or black. Mites may appear to have a bluish cast.

This pest feeds primarily at night and remains around the base of the plant during the day.

Mites cause brown tipped leaves and stunted plants with a silvery-gray appearance.

When these symptoms occur field-wide treatment may be necessary.

The fall armyworm and its ally, the yellow-striped armyworm, can be extremely destructive on small grains. Larvae of the fall armyworm vary from light green to black. The head is marked with a characteristic inverted "Y." The body of the larva has three yellowish-white lines down the length of the back; on each side is a wide, darker, wavy yellow stripe. The yellow-striped, full-grown armyworm larva is 1 1/2 to 1 3/4 inches long. It has a pair of triangular black spots on each body segment. There are three lines on the back--an outer orange stripe on each side and a middle yellowish-white line.

Armyworm damage is apparent by loss of foliage as it is chewed off by the armyworm population. This can be particularly damaging to the seedling stage of small grains.

A precise economic threshold for armyworms is not available, therefore the need for insecticidal control should be determined based on the amount of seedling plant loss.

Other insects such as chinch bugs occasionally damage small grains by sucking plant juices. The chinch bug is a small, 1/8 inch long, black bug with whitish wings and whitish triangular-shaped marks on each side of its back. Grasshoppers also may cause occasional damage as foliage feeders, particularly along borders of fields.

Again for additional information consult Texas Agricultural Extension Service publications L-819, *Greenbugs and Other Aphids on Sorghum and Small Grains* or MP-339, *Suggestions for Controlling Insects and Mites on Corn, Sorghum and Small Grains*.

Field corn insects

An effective pest control program in corn, as with other crops, is an integrated program based on properly timed insecticide applications; biological, cultural and mechanical control and planting insect-resistant varieties as available.

The Southwestern corn borer is a key pest of irrigated corn, especially in the Texas High Plains.

Eggs of the Southwestern corn borer are flat, oval and translucent white. The adult female moth lays them in overlapping chains or groups. The eggs change color to reddish-brown before hatching.

The egg hatches in about 5 days and the larva which emerges is a dull white, yellowish color. The larva has a regular pattern of dark-brown polka dots and is 1 1/4 inches long when fully grown. About 25 days after hatching, the larvae of the *first* generation pupate and in 8 days they emerge as adults.

The borer damages the corn by tunneling in the stalk. This tunneling weakens the stalk making it susceptible to lodging from wind and harvesting equipment.

Chemical control of the Southwestern corn borer usually is not required until second generation adults are present. Careful field inspection is necessary to locate egg masses deposited on leaves in the middle one-third of the plant. The eggs hatch and larvae feed on leaves for 2 to 3 days before tunneling into the stalk.

Apply insecticides when 35 percent of the stalks are infested with eggs and small larvae. Do not apply insecticides prematurely because of destruction of beneficial insects which in turn may produce a spider mite outbreak.

Several species of spider mites occur on corn. The Banks grass mite is the predominant damaging species.

Eggs of the Banks grass mite are laid in the webbing produced by the mites. The eggs hatch in 3 to 4 days under optimal conditions into six-legged larvae. The larvae later develop into an eight-legged nymph. Both are white with dark green spots in color. The nymph then develops into an adult.

Although mites may be observed earlier in the growing season, the population increases after the tassel stage of growth. Initial infestation appears in the lower leaves and then the mites move up the plant. Damage is observed initially as a bleaching of the leaf tissue followed by a silver mottling of the leaf and leaf desiccation. Lodging may occur in severe infestations.

Hot dry weather favors rapid mite buildup. Treat when mites and webbing are easily visible on the middle one-third of the plant with visible damage on the leaves. Mite populations have developed resistance to several pesticides making control difficult.

Occasional pests that attack corn, such as the corn earworm, fall armyworm and armyworm, rarely cause damage. Although some feeding in the whorl stage may be noticed; control is seldom justified. Damage in ears by corn earworm again rarely justifies control. Continual field inspection for all insect pests is necessary. One can never be certain when key pests or occasional pests may cause unexpected damage.

For additional information and background material, refer to the Texas Agricultural Extension Service publication MP-339, *Suggestions for Controlling Insects and Mites on Corn, Sorghum and Small Grains.*

Rice insects

Several insects are found on rice and may inflict economic damage. Among the more important key insects are the rice water weevil, armyworms, rice stink bug and differential grasshopper.

The rice water weevil or root maggot is the most common and probably the most destructive rice pest. The adult weevil is a small, 1/8 inch, dark-brown to black, snout-type beetle that is overlooked easily. The rice water weevil larvae called root maggots, are small pearly white worms.

The rice water weevil attacks the rice plant in both adult and larval stages. The adult weevil spends the winter in Spanish moss and fine matted grass. The adults move into rice fields from late March to the latter part of May and begin feeding on the rice leaves. Before flooding, the adults feed only at night. After flooding, they feed night and day. Adult feeding scars on the leaf is thought to be of noneconomic importance. Some egg laying takes place before flooding, however, the majority of egg laying takes place after flooding. Eggs are laid beneath the soil surface and are inserted in principal roots. Larval feeding in the roots causes the greatest damage. The damaged root system frequently will appear black and decayed. The entire root system can be destroyed causing plant lodging. Root pruning reduces plant height, slightly delays maturity and reduces yield.

Peak root maggot populations usually occur about 3 weeks after the permanent flood and then decline. Adults which develop from these maggots often leave the field and fly to younger rice after this 3-week period of maggot development.

Because of the nature of rice water weevil population development, insecticides must be applied at the proper time. Presence of rice water weevils must be determined by careful field inspection. Apply labeled granular insecticides 7 days after permanent flood. The flood water should be held at least 1 week following the application. Apply only one application of the recommended granular insecticide per season. Do not apply propanil following carbofuran or metalkamate application.

The fall armyworm commonly is encountered in rice production. During some years it causes extensive damage and/or stand loss to seedling rice. The economic damage caused by this foliage feeding larva is not completely clear. Yield loss does increase with leaf removal, even though damaged plants normally recover. Usually damaging infestations develop in circular spots but will not affect all plants within the field.

The economic threshold of the fall armyworm in rice has not been clearly defined. Based on good judgment, apply insecticides when armyworms are present to prevent significant foliage loss.

The rice stink bug is an important pest in some years. It damages rice more from lowering quality rather than actually reducing yield.

The adult stink bug is a straw-colored, shield-shaped bug ranging from 3/8 to 1/2 inch long. The rice stink bug can be distinguished from other stink bugs by its more elongated shape and the sharp forward-projecting shoulder spines.

Rice stink bugs usually come out of overwintering quarters in late April and early May and feed on seeds of wild grasses which are heading. Migration to rice occurs when these wild grasses mature and dry up or when sorghum or early rice fields are harvested.

The female adult lays tiny barrel-shaped eggs on the leaves and heads of rice. The eggs hatch and the immature nymphs require about 2 1/2 to 3 weeks to mature to adults.

The nymphs and adults damage the developing grain by puncturing the grain and extracting fluids. Grain attacked in the milk stage will not develop. The stink bug will continue to feed on grain in the dough stage. Feeding in the dough stage sometimes allows certain fungi to enter the seed and cause a grain with a black spot. This is commonly termed pecky rice. These pecky grains break in the milling process reducing the percentage of whole grain.

Careful field inspection is necessary, as with all insects, to determine if damaging levels of rice stink bugs are present. Use a standard 15 inch sweep net as a sampling tool. A single sweep constitutes a half-circle (180°) swing, parallel to the ground through the rice heads. Start sampling before 10 percent of the heads turn over. An insecticide application is warranted when 10 or more stink bugs are found in 10 sweeps. Continue field inspections after the initial application or the stink bugs may migrate into the field from surrounding crops.

Commonly, insecticides are applied too early before economic infestations of stink bugs are present. This usually destroys the natural parasites and predators of the rice stink bug and requires additional costly application.

Many species of grasshoppers reside in rice. Of these only 1 or 2 species are potentially damaging. The differential grasshopper is often an important pest because unlike other grasshoppers that usually feed moderately on foliage and old flowers, the differential grasshopper feeds on the stem.

The differential grasshopper is a rather large yellowish to yellow-brown insect with a round head. The head's of other noneconomic species usually are pointed or cone-shaped.

Damage from stem feeding of the differential grasshopper causes plants to produce white or blasted heads due to early feeding before panicle emergence. Judgment based on frequent field inspection is necessary to determine the need for chemical control of the differential grasshopper. Apply insecticides when damage is evident before or during panicle emergence. Continuously inspect fields as grasshoppers will migrate into rice from surrounding pasture lands.

Other insects that may occasionally damage rice are stalk borers. These include the sugarcane borer and the rice stalk borer. These insects tunnel within the rice stem causing failure of head emergence or blasted heads. These insects occur only sporadically in Texas and as yet data have not been developed to determine their economic threshold.

Additional information available from the Texas Agricultural Extension Service includes Entomology Notes--Rice Insect Control and a mimeographed handout *Insects Affecting Rice Yields and Quality and their Control*.

Forage crop insects - legumes and grasses

Management of insect pests on alfalfa, forage sorghums and permanent and improved pastures requires a working knowledge of the pests involved and recognition of the type and extent of damage caused.

Alfalfa for hay in seed production may encounter a variety of pests. Some of the more important pests include aphids, stink bugs, alfalfa caterpillars, lygus bugs, alfalfa weevils and armyworms.

Two aphid pests of alfalfa are the spotted alfalfa aphid and the pea aphid.

The spotted alfalfa aphid is a pest found where aphid-resistant alfalfa varieties are not grown. The spotted alfalfa aphid is pale yellowish green and has 4 to 6 rows of spots bearing spines on its back. Both winged and wingless forms may be present. Damage from this insect is caused by juices being sucked from leaves and tender stems. A toxin is injected into the plant by the aphid which interferes with growth and causes the leaves to turn yellow and drop from the plant. As with all aphids, honeydew is excreted in which sooty mold grows, thereby making harvesting and baling operations difficult.

The pea aphid is bright green and long legged, about twice the size of the spotted alfalfa aphid. Pea aphids do not inject toxins into the plant as they feed on leaves and tender stems; however, heavy feeding in the spring, early summer and fall may cause plant stunting or death.

Seedling stages of alfalfa are more susceptible to damage from the pea aphid and the spotted alfalfa aphid.

Insecticide treatment of these aphids is based upon the number of aphids per plant and damage caused based upon field inspection.

Alfalfa should be treated with a registered insecticide when 20 to 40 spotted alfalfa aphids appear per stem on established stands and when plants begin to get sticky with honeydew. Similarly, when 150 pea aphids per plant are found and plants are showing stress, a treatment should be applied. Treat seedling alfalfa when either spotted alfalfa or pea aphids are observed in small numbers. Seed alfalfa can tolerate fewer of either aphid species.

Lygus bugs and stink bugs can inflict damage in alfalfa seed production. Lygus bugs can be serious pests of alfalfa seeds. These insects, 1/4 to 1/3 inch long, are flattened and vary in color from yellow or brown to dark brown or almost black.

Lygus bugs damage seed alfalfa by feeding on buds, blossoms and developing seeds. Sample alfalfa with a standard 15-inch sweep net when the wind velocity is less than 10 miles per hour in the early morning or late afternoon. Randomly take 100 sweeps across the field. Count all immature, wingless nymphs as 2. The economic threshold, number of lygus bugs per 100 sweeps, varies with the plant growth stage (75 for the green bud stage, 100 for the bloom stage and 120 to 150 for the soft-dough stage).

The alfalfa weevil damages both seed and hay alfalfa. The adult weevil is a snout beetle about 3/16 inch long. The young adult weevil is light brown with a broad dark stripe running about halfway down its back. Older weevils are darker in color. Eggs are a bright lemon yellow when they are first laid in masses in alfalfa stems. Newly hatched larvae have a cream color with a shiny black head. As they grow older, they turn light green. As they mature, they reach a length of 3/8 inch and turn dark green with a yellowish-white stripe down the middle of the back.

In most parts of Texas, only one generation is produced per year. Weevils usually become active in late fall in South Texas and early spring in more northern parts of the state.

The weevil larva causes damage to alfalfa from early winter to early spring. The first hay crop usually receives the most damage. Upon hatching, the larvae feed in the upper plant tips. As they grow, they feed on remaining plant foliage and skeletonize the leaves. Alfalfa fields first damaged take on a greenish-gray appearance. As the leaves dry and fall from the plant, the field appears grayish-white. At times the alfalfa weevil may damage the second crop.

If an alfalfa field is infested with weevils, cut the first crop cleanly in the bud stage. If insecticide applications are needed to prevent damage, careful field inspection is necessary. Begin treatment when 25 to 30 percent of the alfalfa terminals show feeding damage or when 25 or more larvae are found per square foot. Two applications may be necessary.

Other insect pests such as alfalfa caterpillar and armyworm feed on alfalfa foliage and may damage buds. Base treatments on excessive foliage reduction caused by the pest.

Several insect pests attack forage sorghum and improved, temporary and native pastures. Of these, grasshoppers and armyworms are considered key pests.

Grasshoppers are the most important pests of native pastures. Development of grasshopper populations in hatching areas in the spring and early summer should be checked carefully. Once these sites are located, insecticides can be used effectively before the grasshoppers disperse into larger areas. When 7 to 10 grasshoppers are found per square yard, accompanied by excessive leaf loss, apply an insecticide.

Control the armyworm and the fall armyworm with a labeled insecticide before excessive foliage loss.

MP-1014, *Texas Guide for Controlling Insects on Legumes and Grasses* and B-975, *Insects Attacking Forage Crops* can be obtained from the Texas Agricultural Extension Service for additional information.

Peanut insects

Peanuts are attacked by several insects in Texas. These include the lesser cornstalk borer, the burrowing bug and certain foliage feeding insects.

The lesser cornstalk borer is a key pest of Texas peanuts. This small, slender, bluish-green larva with brown stripes is a subterranean feeder living beneath the ground in silken tubes.

Late planted peanuts may be damaged in the seedling stage. During periods of dry weather higher populations are common. Peanuts from 35 to 75 days old may suffer economic damage. Larvae damage mature plants by feeding on pegs, pods, stems and roots.

As with other pests, carefully inspect fields weekly for lesser cornstalk borer. Dryland peanuts in dry years are particularly susceptible to damage.

Select inspection points at random with 1 location per 5 acres. Select a minimum of 5 sample sites per field. Five plants should be examined carefully at each site for feeding damage, larval tubes or larvae. Later in the season peanuts should also be inspected.

Determine the percentage of plants infested to know when to treat. Before initial pegging, infestation levels greater than 5 percent in dryland peanuts and 10 percent in irrigated peanuts require treating. However, after initial pegging treat dryland peanuts when infestation levels are greater than 10 percent and when greater than 15 percent on irrigated peanuts.

The burrowing bug is a peanut pest in South Texas. This beetle-like bug is oval shaped, dark brown to black in color and about 1/4 inch long.

Burrowing bugs migrate into peanut fields in midsummer and are found beneath the soil surface. These bugs damage peanuts by attacking developing nuts resulting in a mottling of kernels, as well as grade reduction. Damage occurs *only* when young or maturing nuts are present. During this critical

period, inspect peanut plants for burrowing bugs or damage. If they are present, apply a granular insecticide no later than 25 to 30 days before harvest.

Foliage feeding insects such as the corn earworm, rednecked peanut worm, armyworm, saltmarsh caterpillar and grasshoppers may periodically damage peanuts. The peanut plant tolerates relatively high numbers of foliage feeders per foot of row without suffering yield reduction.

Because the peanut plant is most susceptible to foliage feeder damage between 60 and 90 days of age, frequent field inspections are required to determine the need for insecticide control based on foliage loss.

For additional information on peanut insect management consult L-704, *Managing Insects on Texas Peanuts* published by the Texas Agricultural Extension Service.

Soybean insects

Insects that attack soybeans are described by the type of damage they inflict upon the plant. These insects are stem or stalk feeders, foliage feeders and bean or pod feeders.

Of the stalk feeders, the three-cornered alfalfa hopper is the most important. The adult hopper is triangularly shaped and greenish in color. It is about 1/4 inch long. The adult deposits eggs in the stem. The eggs hatch into brownish spring nymphs. As these nymphs mature, they take on the green color of the winged adult.

Damage from the three-cornered alfalfa hopper comes from a girdling effect as the nymphs and adults feed in a ring around individual stalks and stems. Damage also is experienced from adult egg-laying activity. Plants are frequently stunted somewhat, but the main damage is caused by weakening of the stems to the point where older stems break off at the girdled area. Large infestations of three-cornered alfalfa hoppers may cause considerable stand loss in young soybeans.

As most damage is inflicted to soybean plants before bloom, carefully inspect the fields in several locations for girdling and the presence of hopper nymphs. If nymphs are present and 10 to 15 percent of the stems are girdled, an insecticide application is necessary to prevent economic loss.

Other insects that may feed on soybean stalks are cutworms and the lesser cornstalk borer. These insects only cause damage sporadically.

Several insects feed on the leafy foliage of the soybean plant. Most leaf feeders are classed as minor pests because of their small populations and the soybean plant's ability to withstand considerable foliage loss without reduction. Some of the more important leaf feeders are presented in the following paragraphs.

The bean leaf beetle. This reddish to yellowish dark spotted insect closely resembles the spotted cucumber beetle in size and color. It also resembles

several lady beetles which occur in soybean fields. Generally, these pests chew shot holes in the leaf. The green cloverworm is a light green, slender worm with three indistinct lines down its back. This insect chews jagged holes in the leaf. The velvetbean caterpillar also is light green with distinct dark lines down its back in older worms. Damage from this insect is similar to the green cloverworm. The yellow-striped armyworm and its cousin, the fall armyworm, damage soybeans by skeletonizing the leaves. Blister beetles are long, cylindrical insects. Common blister beetles are the striped blister beetles and the margined blister beetles. Both species chew ragged holes in the leaf.

Depending upon the stage of growth, the soybean plant can withstand up to 40 percent defoliation without yield loss. Make a careful field assessment of foliage loss throughout the season.

From the time of emergence up through the blooming period, the soybean plant can withstand 40 percent defoliation without important yield losses. Understandably, leaf function is most important during the pod formation period. When pods are forming and beginning to fill out, however, a 20 percent foliage loss will decrease yield. After pods are fully filled and the beans are nearing maturity, up to 35 percent defoliation will not cause yield reduction. Thus, the growth stage and an estimate of the percent defoliation are very important in determining the necessity for insecticide applications.

Stink bugs and corn earworms have the potential of reducing the quality or quantity of soybeans by feeding directly on the pods.

Two types of stink bugs generally cause damage to soybean pods. These are the southern green and the brown stink bug. The nymphal stages are oval-like, while the adults are characteristically shield-shaped. Damage by stink bugs usually causes spotting of the beans resulting in a grade reduction.

The ever present corn earworm or podworm causes damage to soybeans by directly feeding on pods and developing or maturing beans.

As with all insects, determining the infestation level of pod feeders is the first step in determining the need for insecticide applications on soybeans. Check 3 feet of row in 10 spots per field weekly. These 3-foot checks should be scattered over the field so that an adequate sample of the entire field can be taken. In these 3 feet of row at each location, shake the plants over a white cloth laid in the middle. A 2-foot X 3-foot cloth is satisfactory for making these counts. Count the number of corn earworms and stink bugs that are dislodged from the plants at each location. As you move across the field, determine in your own mind the degree of defoliation from foliage feeding insects at the same time. This, of course, will be strictly an estimate, but it will serve as a guide in determining the need for control of foliage feeders. After making your counts as suggested, determine the need for controlling pod feeders according to this guide. If you find 30 corn earworms per 30 feet of row or an average of one earworm per row foot, or 10 stink bugs, this constitutes an economic infestation level.

*Soybean Insect Control Suggestions* and *Soybean Insects*, a color plate series of insects attacking soybeans is available from the Texas Agricultural Extension Service.

## REVIEW QUESTIONS

## FIELD CROP PEST CONTROL--INSECTS

1. Key insect pests that damage cotton during very early season are:

   a) thrips
   b) pink bollworm
   c) tobacco budworm
   d) none of the above

2. The adult boll weevil lays most of its eggs in:

   a) stems
   b) leaves
   c) 1/3-grown squares
   d) large bolls

3. The greenbug is:

   a) light green with a dark green stripe
   b) bluish green
   c) lemon yellow
   d) dark pink

4. A pod feeder of soybeans is:

   a) grasshoppers
   b) three-cornered alfalfa hopper
   c) corn earworm
   d) lesser cornstalk borer

5. Peanuts are not attacked by:

   a) root feeders
   b) kernel feeders
   c) greenbugs
   d) foliage feeders

6. Field corn is damaged by:

   a) southwestern corn borer
   b) lacewing fly larvae
   c) burrowing bug
   d) none of the above

7. The economic threshold for boll weevil in mid-season is:

   a) 5-10% punctured squares
   b) 10-15% punctured squares
   c) 15-25% punctured squares
   d) 45-60% punctured squares

8. Small grains are damaged by:

a) blister beetles
b) greenbugs
c) parasites
d) none of the above

## FIELD CROP PEST CONTROL - PLANT DISEASES

Producing a healthy crop in a profitable manner is the objective of disease control on field crops. Much research and Extension work has been done to determine the most effective method of controlling diseases of field crops. In fact guides have been prepared to make very specific recommendations for controlling most diseases on most major field crops.

Field crop diseases are caused by fungi, bacteria, nematodes and viruses. These are microorganisms and cannot be seen by the unaided eye. For this reason we are concentrating on recognizing symptoms and understanding the nature of disease development.

There are many field crops grown in Texas, and it is necessary to concentrate on those where chemical application is most often considered. In most cases the common diseases are considered for those crops discussed whether chemical control is feasible or not. In many instances these may be confused with other types of damage where chemical control might be employed.

Peanuts represent an important crop in many areas of Texas. Peanut leaf spot is the most common disease on the crop. The fungus which causes this condition is distributed widely and causes severe losses annually, if chemical control is not used to prevent that damage. This fungus produces spores that are blown to the foliage of the peanut plant. Protectant fungicides must be used to control this condition.

Rust is another disease of peanuts that occurs in certain areas of the state during certain years. This can be a very destructive disease and must be prevented with protectant fungicides. This disease is caused by a fungus that produces wind blown spores. If the disease occurs heavily in a certain area, it is likely to produce spores that will be transported and cause problems in other areas.

Atmospheric scorch is a condition that many producers call rust. This is caused by atmospheric ozone produced by thunderstorms or smog from large cities. No chemical control for this condition exists.

Web blotch is a difficult-to-control fungal disease beginning to develop in Texas. Certain fungicides, however, are effective in reducing the incidence of damage caused by this disease.

It's important for a producer to know if web blotch is occurring. If it is, one needs to use shorter fungicide intervals and check coverage of the foliage to achieve satisfactory control.

Weather is an important factor in foliar disease development on peanuts. Warm temperatures and high humidity result in more development of foliar diseases on peanuts.

Use hygrothermographs to check actual weather conditions occurring in peanut vines. This indicates whether conditions are favorable for development

of foliar diseases. This method is used more extensively in Texas with a few producers using weather reports.

Recommendations for controlling foliar diseases of peanuts are revised each year. Not all fungicides control all foliar diseases. It's necessary to be very specific and know exactly which materials control the different types of diseases. It is necessary also to know how long these materials will last on the foliage surface. If the interval is extended too far, it is impossible to receive adequate control. Money may be lost on applications because they are not sufficient.

Recommendations vary between dryland and irrigated peanuts. Specific disease control recommendations are made according to how the peanuts are produced. The recommendation for irrigated peanuts is rather automatic. Conditions favoring disease development are met when sprinkler irrigation is used. This requires the regular use of foliar fungicides to prevent the most devastating diseases. For dryland peanuts, one can take a wait-and-see approach. It is necessary to be a good observer to make the system work. If one is dedicated to determining the exact time at which disease starts to develop, money can be saved by less applications to get adequate control to prevent yield loss.

Tolerance has developed in certain states to the fungicide benomyl. This fungicide is very specific and controls leaf spot on peanuts. It is still effective in Texas, because additional materials have been used with benomyl. Suggestions given are necessary to prevent the development of resistant strains of the leaf spot fungus in a given field.

Nematodes cause severe problems on peanuts. Speckling of pods is caused by root lesion nematodes entering pods. This type of nematode can be controlled by preplant and postplant applications of recommended nematicides. When damage from root lesion nematodes is severe, considerable yield loss occurs.

Root knot nematodes constitute the most serious nematode problem on peanuts. This may totally reduce the yields in certain areas of the field. Again, chemical control is effective in preventing this condition. There are no resistant varieties.

The root knot nematode has disfiguring effects on the nuts. It causes shell enlargement and reduces the size and quality of the nuts. Yield and quality loss are substantial if root knot nematodes are not controlled.

Chemical control recommendations are made annually. Chemicals recommended have proven effective in giving good economical control of nematode problems on peanuts. To be effective, apply them in accordance with label recommendations. They are available in liquid and granular forms.

Applying volatile nematicides results in treating a soil column. Ideally one will plant in treated soil. If the total soil mass is not treated, nematodes are not completely eliminated. Populations are lowered, however, to the point where a reasonable crop can be grown.

Very carefully check application equipment to determine the depth of the nematicide. If it is applied too deep or too shallow, results will not be as good. The nematicide can cause damage if applied too shallow. If applied before seeding or if the seeds are placed in the direct concentration of the chemical, ineffective control and damage to the crop result.

Pythium pod rot is caused by a fungus. No chemical control for this condition exists and one must rely on cultural control, such as avoiding over irrigation.

Southern blight is an extremely common disease in peanuts. It can be controlled very effectively with cultural and chemical means. It is caused by a soil-borne fungus that produces a white type of fungal growth. It can be controlled chemically with a granular material called PCNB.

There are a number of different types of cultural control that can be used to prevent damage from southern blight. A producer should use as many control systems as possible to control any individual disease. If a chemical is used, one should be especially careful to use cultural controls also.

More than 55 million acres of soybeans are grown annually in the U.S. Soybeans are an economically important crop; not only do they provide protein for animal feed, but a large portion of soybean meal goes into human consumption. Soybean diseases reduce yields in Texas annually by an average of 15 percent. Disease severity ranges from light in the High Plains to moderate in the Northeast and severe in the Gulf Coast regions of Texas. Presently, the most economically damaging soybean diseases are caused by fungal organisms. Recent developments in the use of fungicides require proficiency in soybean disease identification.

One of the most important problems faced today is availability of high quality seed. Many soybean diseases are carried over from year to year on the seed which causes seedling disease problems. High quality seed averages eight plants per foot while the poor quality seed yield only three plants per foot. Using seed treatment material either as a hopper box material or as a seed treatment will improve the stand.

A small hand lens can show the difference between good and poor quality seed. Poor quality seeds are shriveled and often discolored.

Charcoal rot or summer wilt appears in hot, dry weatner or when plant growth is retarded by unfavorable environmental conditions. In Texas charcoal rot generally appears in mid-season. Infected plants at first do not show above ground symptoms. As the disease advances leaves turn yellow, plants wilt and die and the leaves remain attached. Charcoal rot generally appears in areas of the field which undergo stress caused by moisture or fertilizer.

When the epidermis or outer bark is removed, small black sclerotia are present along the stem; streaks or discolored tissue will be found in the woody portion of the stem. These small black sclerotia or overwintering bodies may survive in the soil for years. Control measures for this disease include avoiding excessive seeding rates, fertilizing where needed to encourage vigorous growth and irrigating where possible when plants undergo stress.

Southern blight or Sclerotia blight occurs worldwide, but does not generally cause economic losses. This fungus produces a variety of symptoms including pre and postemergence damping off, basal stem rot and leaf spot. On seedlings and stems, the fungus produces a white, cottony growth over the stem surface. Infected seedlings or older plants often are killed prematurely. Generally this disease only attacks scattered plants in a field. The disease is more severe in sandy soil when air and soil temperatures are high. Control for this disease includes rotating with nonsusceptible crops and reducing organic material in the soil by deep plowing.

Texas root rot or cotton root rot generally occurs in early summer and causes rapid wilt followed by plant death within a few days. Usually plant leaves do not shed. The disease kills plants in circular areas ranging from a few square yards to an acre or more in size. In an infected plant the whole root system decays and plants are easily pulled from the soil.

Rhizomorphs or fine brownish strands of fungal threads usually are found on the root system of plants infected with cotton root rot. Under moist conditions spore mats may appear on the soil surface near diseased plants. These spore mats range from 2 to 12 inches in diameter. They are snow white and cottony, later turning tan and powdery. The best control of cotton root rot on soybeans is to avoid old cotton land or land where cotton root rot has been a problem before. Deep plowing 12 to 18 inches with a mold board plow may help reduce the disease.

Frog eye leaf spot generally appears late in the growing season. This disease may affect leaves, stems and pods, but is most conspicuous on leaves where it causes a leaf spot lesion composed of a tan or gray central area surrounded by a narrow red border. Severely infected leaves may fall prematurely. The disease is seed borne and may overwinter on infected leaves and stems. Control measures include planting disease-free seed, plowing under crop residues, rotating crops and applying foliar fungicides.

First symptoms of downy mildew are indefinite yellow-green areas on upper leaf surface. Later these areas become light to dark brown spots with yellow-green margins. Grayish downy tufts with mold appear on the lower surfaces. Severely infected leaves may fall prematurely. The disease spreads by infected seed and overwinters on plant debris. Use of crop rotation and disease-free seed are the most effective disease control practices.

Target spot occurs primarily on leaves, but may occur on pods and stems. Spots on leaves are reddish brown circles and vary in size from very small to more than ½ inch in diameter. Large spots are composed of concentric rings. This fungus is a weak parasite and usually attacks plants too late in the season to cause severe damage. Planting disease-free seed, rotating crops and plowing under residue are the most effective control means.

Aerial web blight is a new disease recently causing problems in Texas. First symptoms appear as water soaked lesions or spots on the leaves. As the disease progresses, lesions become dark brown and the center of the spot dries up and falls out.

A close look at aerial web blight in the field shows severe defoliation with some leaves totally gray still attached to the plant. Control measures for this disease include well drained fields and crop rotation.

Bacterial leaf spot on soybeans generally develops during cool, wet weather. The disease first appears as small angular spots on leaves, varying from yellow to brown. These spots later dry and portions of the leaves drop out giving a torn, ragged appearance. Bacteria may overwinter in crop residue. Control includes planting disease-free seeds, deep plowing and rotating with nonsusceptible crops.

Soybean mosaic virus is the most common virus disease in Texas. Infected plants show a yellow vein clearing in the small branching veins of developing leaves. Infected leaves are narrower than normal, margins turn down and later become ruffled and blistering occurs along the veins. Leaves become leathery and brittle and infected plants produce misshapen pods and fewer seeds.

The virus is carried on infected seeds which are discolored and misshapen. There is no known control for this disease.

Diaporthe stem blight generally occurs as plants near maturity. This disease is identified by numerous small black fruiting bodies on stems and pods of infected plants. These pycnidia are arranged in linear rows on the stem and scattered on the pods. This fungal organism infects the seeds and causes them to shrivel, mold and be small. Infected seeds may appear normal, but when infected seeds are planted, the embryo may be killed before emergence, or the seedling may be killed in an early stage. Delayed harvest results in increased incidence of this disease, especially if high moisture and high temperatures prevail. Control includes early harvest when weather conditions permit and effective use of a foliar fungicide.

Anthracnose, a fungal disease, infects stem petioles and pods of plants nearing maturity. Dark brown or reddish brown areas may cover the surfaces of the infected stems and pods. Later the infected area may become black with the fruiting bodies of the fungus. Dark brown sunken cankers appear on the cotyledons of the young seedlings and lower branches may die. Seeds and infected pods may shrivel and mold and show no external signs of the disease. The fungus is carried over on the seeds and germinating seeds may be killed before emerging. Control includes the use of disease-free seeds, crop rotation and application of a foliar fungicide.

Soybeans in the Gulf Coast area of Texas are infected by several diseases including Diaporthe stem blight and Anthracnose as well as Cercospora purple seed stain as evidenced by silvery colored pods near the upper portion of the plant.

Mature seeds infected with purple seed stain are discolored. Discoloration may cover a small area or the entire area of the seed surface. Affected seeds may be cracked, rough and dull; seed quality is low. When infected seeds are planted, the fungus grows from the seed coat and infects the seedling. Crop rotation, use of disease-free seeds and applications of a foliar fungicide will aid in preventing this disease.

To obtain clean disease-free seeds a six-step disease control program should be followed.

1. Plant high quality seed
   a. Germination greater than 85 percent
   b. Germination and vigor measured by:
      1. Cold seed test
      2. Accelerated aging test
   c. Low percentage moldy seed

2. Plant seeds produced in low disease incidence fields
   a. Rotation
   b. An approved fungicide - sprayed seed field

3. Apply two, ½-pound applications of an approved fungicide
   First spray when approximately 60 percent of the pods are set.
   Note: Pods will be from ¼ to 1 inch long.

4. Aerial applicator should:
   a. Make plans to leave untreated area for comparison
   b. Apply fungicides--
      1. With a minimum of 5 gallons of water per acre
      2. In a uniform pattern
      3. Flying 6 to 8 feet above crop (maximum)

5. Harvest as soon as possible after beans are mature. If a desiccant is used, make sure it is applied after maturity.

6. Practice crop rotation.

Grain sorghum is another field crop with a number of diseases; unfortunately most of these diseases cannot be controlled chemically. Since chemical control is used on grain sorghum and corn, however, we will discuss the common diseases so that confusion in diagnosis will not occur.

Downy mildew produces one of the more striking symptoms of any sorghum disease. This is a serious problem along the Gulf Coast and inward for approximately 150 miles. This disease is caused by a soil-borne fungus that infects the plant at a very early age and causes it to be sterile. No heads are formed and consequently yields are totally lost on infected plants. Resistant varieties are satisfactory in controlling this condition.

Downy mildew gets its name from the down or fuzzy growth produced on the underneath leaf surface. These spores are capable of being blown to other plants, causing infection. The leaf infection phase of this disease is not as severe as systemic infection.

Systemically infected plants shred during the season and are stripped as if subjected to a hailstorm. This occurs because spores are produced between the veins of the leaf.

Overwintering spores are capable of surviving in the soil up to 10 years. They germinate in the spring when sorghum and corn are planted and cause infection when the plant is very young. Chemical controls have been ineffective in preventing this type of infection. Many fungicides have been tried, but none have given satisfactory control.

Maize dwarf mosaic is a disease of sorghum and corn that causes yield loss. This disease is caused by a virus transmitted by aphids. The virus causes a lighter colored plant and shows a mottled appearance on the foliage. Infected plants are stunted and produce smaller heads or ears.

Maize dwarf mosaic on corn produces basically the same symptoms as on the sorghum. One can very easily see the mottled appearance on the leaf surface. This condition cannot be controlled chemically and resistant varieties must be used to prevent damage.

Do not confuse maize dwarf mosaic with iron chlorosis. Iron chlorosis results in a striped leaf with the veins remaining green. It can be controlled chemically so diagnosis of these problems is extremely important.

Maize dwarf mosaic produces yet another symptom besides the mottling. The red leaf symptom is produced when a susceptible hybrid is grown. This symptom develops when plants become infected and night temperatures are below 55°F.

Many leaf spot-causing organisms affect grain sorghum. Currently chemicals are cleared for use in controlling leaf spots of grain sorghum. Materials have been tested and some are effective, but none are recommended at this time. Resistant hybrids have been effective in reducing the incidence of these leaf spot diseases.

Head smut of grain sorghum is a serious disease. New races have developed which affect the so-called resistant grain sorghum hybrids. The smut ball consists of thousands of tiny fungal spores that fall to the soil and can cause infection of seedling plants. No chemical control exists and resistant varieties should be used. Resistance to the new race is currently being researched and hopefully will be available soon.

Head mold occurs on sorghum when the weather is humid and conditions are unfavorable for harvest after maturity. Nutrients leach from the seeds and fungal organisms develop on that food source. No chemicals are cleared. Harvest grain as soon as possible after maturity.

Southern corn leaf blight is a fungal disease of corn. It has been serious in some previous years on corn with sterile cytoplasm. Seed corn containing normal cytoplasm does not produce a plant susceptible to this disease. Chemical control is effective in preventing this disease on sterile cytoplasm field corn and on sweet corn.

Southern corn leaf blight is caused by a fungus. This spore can be wind blown to fields far away. When weather conditions are favorable, spore germination takes place and penetrates the leaf surface.

Southern corn leaf blight can be devastating especially on sweet corn. Chemical control with a maneb-type fungicide is effective. It is cleared for use by the EPA and one should be careful to follow the exact label instructions.

Many stalk rots of corn occur. No chemical control is effective and growers must rely on cultural practices such as crop rotation and proper handling of crop residue to control this condition. Stalk rots are likely to be much more severe when corn follows corn each year.

Like grain sorghum and corn, cotton has many diseases also. Cotton seedling disease also is one of the first ones a producer sees each year. It kills young seedling plants and causes large skips in cotton stands. Chemical control is effective in reducing incidence of this disease.

Seedling disease is caused by a number of fungi that live in the soil. Producers can control this condition by using in-furrow fungicides when planting. Using high quality seeds also reduces the incidence of this disease condition.

Wet weather blight, sometimes called Ascochyta blight, causes damage to young plants. This usually occurs when the weather is very wet and humid and soil temperatures are cold. Sometimes it causes complete stand destruction, but usually it only reduces plant vigor. No chemical control is recommended for this condition.

Bacterial blight causes several different symptoms on cotton. The most common symptom is the angular leaf spot effect produced on leaves. It also affects the stems and bolls and reduces lint quality. Resistant varieties are the most satisfactory means of control. No chemicals are recommended for controlling this condition.

Fusarium and Verticillium wilt produce a vascular discoloration in the stems of cotton plants. This prevents proper translocation of water and nutrients and causes the plant to wilt and die. Verticillium is more of a problem in West Texas with Fusarium a problem in East Texas.

Cotton root rot is caused by a fungus which lives in certain soils. It kills cotton and approximately 2,000 species of other plants. It occurs readily in certain areas of the heavier soils through central Texas. Chemical controls are being investigated, but none are recommended at this time. Early planting with early maturing varieties may help prevent the disease. There are no resistant varieties.

Cotton boll rot is common in very heavy cotton growth. If excessive stalk growth has occurred, one may encounter boll rot problems. Reducing some of the leaf tissure with the selective use of defoliants may be a practical answer. Chemical control fungicides have been tested and used to some extent. Use of this practice is only minimal because of the cost of materials.

Texas rice producers grow more than 450,000 acres of rice annually. They are encountering more and more disease problems as rotations are shortened due to lack of available farmland. Currently Texas rice losses are approximately 12 percent of the rice crop each year. As intensive farming practices

are followed, high fertility levels and increased organic matter raise the incidence and severity of rice diseases.

Seedling diseases cause spotty, irregular stands through seed decay, pre-emergence and post emergence damping-off. The seedling disease complex results from activity of various kinds of fungi most of which grow on kernels or hulls of seed rice.

As infected seedlings emerge from the soil, they are killed or weakened and become chlorotic in appearance. Damage is most severe on early seeded and deep planted rice. Control measures include seed treatment materials as well as shallow seeding of early planted rice.

Rice blast is one of the most important rice diseases in the world today; it occurs throughout the Gulf Coast rice producing area. Rice blast occurs on leaves. Infection also may appear at the place where the leaf blades join the sheath. Leaf spots are elliptical and rather long with more or less pointed ends; the center of the spot is usually gray and the margin brown or reddish brown. The shape and color of the lesions may vary and resemble those caused by brown leaf spot. The degree and severity of the blast often is determined by weather conditions. Free moisture standing on the leaves is necessary for blast formation.

Blast lesions appearing on leaves have arrow-shaped, pointed ends as well as silvery gray centers.

Rotten neck is caused when blast fungus attacks the panicle and branches of the head. If the panicle is attacked early in the season, grain on the lower portion of the panicle will be blank giving the rice a silvery or white color; thus the term blasted head or rice blast.

In addition, the fungus also may attack the nodes or joints of the stem. When the node is infected, the sheath pulvinus rots, and the part of the stem above the infection is killed.

In many instances the node is weakened to the extent that the stem will break, causing extensive lodging. If infection occurs early and is severe, the whole plant is stunted and loses most of its leaves. Blast generally occurs in scattered areas rather than widespread areas. Late planting, rain and warm weather favor blast development. Control of rice blast includes varietal resistance as well as the use of foliar fungicides.

Narrow brown leaf spot is prevalent in eastern portions of the Texas rice belt. The disease varies in severity from year to year and usually becomes more severe as rice approaches maturity. Symptoms of this disease are long narrow spots, tan or dark brown in color. Leaf death occurs in severe cases of this disease. Early maturing varieties tend to escape this disease. Use of foliar fungicides helps control this particular disease.

Brown leaf spot is the most prevalent and economically damaging rice disease occurring in Texas. Most conspicuous symptoms of the disease occur on leaves and glumes. Symptoms also appear on the coleoptile, leaf sheaths, panicle branches and young seedlings. Brown leaf spot is a seed-borne disease.

Leaf spots are circular to oval shaped and dark brown to grayish in color. Spots vary in size, color and appearance according to rice variety. Leaves may die in severe cases.

Helminthosporium also may appear on the grain. Spots are very similar to those appearing on the leaves; lightweight or chalky kernels may be produced. These spots often are confused with insect injury and cause reductions in grade and price. Damage from brown spot may be reduced through crop rotation and seed treatment fungicides.

Brown border leaf and sheath spot is characterized by large spots which appear on the sheath near the water line. These spots are large with irregular reddish brown borders. Under severe conditions the disease may kill the leaves and cause lodging in limited areas of the field. The disease is most prevalent in warm moist seasons and occurs where stands are thickest.

The small black round body on the rice sheath are Sclerotia or resting bodies of the brown bordered leaf and sheath spot organism. These Sclerotia overwinter in the soil or on rice refuse. Avoid excessive seeding rates and high nitrogen applications in fields with a history of this disease. Control grass and weeds.

Leaf smut is a minor fungal disease. Small slightly raised, black spots develop primarily on the leaves. The gray spots or pustules contain black spores of the smut fungus. When spores mature, the pustules break open releasing air-borne spores. Infection often is heavy enough to kill tips of leaves although leaf smut occurs late in the growing season and causes little or no yield losses.

Unlike leaf smut, kernel smut causes losses in yield and quality. The endosperm of the grain is attacked by the fungal organism causing either part or all of the starchy material to be replaced by a black mass of smut spores. Smut is detected more easily after a rain or in early morning following a heavy dew. Kernel smut usually is most severe on late planted rice. Although only a small percentage of the kernels is affected, monetary losses are greater because of penalties levied on the grain at the drier.

Release of the smut spores from within the kernel causes a discoloration of the hulls. High nitrogen rates increase the incident of smut. Control measures include using resistant varieties and lower rates of nitrogen fertilizer.

Rice grain may be infected with several fungal organisms before harvest, causing discoloration with severity varying according to the season. Discoloration may appear internally or externally on the grain. Kernel spot is enhanced by injury from insects or high winds. Kernel spots reduce grade and yield of head rice. No control measures other than insect control are recommended.

Stem rot caused by a fungal organism begins to appear later in the growing season. This disease shows up when the permanent flood is removed from the field and the rice begins drying for harvest. The disease occurs in circular to irregular areas in the rice field and causes death.

Stems taken from areas infected with stem rot show water soaked dark areas on the stalk near the base or ground. As the stalks weaken, they break

causing the plants to lodge, thus making harvest difficult. Plants infected early yield poorly.

Diagnosis of stem rot is made by obtaining an infected plant and splitting the plant at the base of the stem. Presence of small black Sclerotia is an effective means of diagnosing the disease. Control measures include crop rotation, lower nitrogen applications and applications of a foliar fungicide.

## REVIEW QUESTIONS

## FIELD CROP PEST CONTROL - PLANT DISEASES

1. Field crop diseases are caused by _____ , _____, _____, and _____.

2. The most important foliar disease of peanuts is:

   a) rust
   b) leaf spot
   c) atmospheric scorch
   d) web blotch

3. Southern blight of peanuts is caused by a:

   a) nematode
   b) virus
   c) fungus
   d) bacterium

4. Cotton root rot on soybeans and cotton generally occurs:

   a) in circular patches in the field
   b) on all plants in a field
   c) only on seedlings
   d) around borders of a field

5. In applying foliar fungicides to soybeans and rice aerial applicators should apply:

   a) 1 gallon of water per acre
   b) 5 gallons of water per acre
   c) 12 gallons of water per acre
   d) low volume only

6. Downy mildew on sorghum; (Mark the <u>two</u> correct answers)

   a) can be controlled with foliar fungicides
   b) cannot be controlled with foliar fungicides
   c) can be controlled with seed treatment
   d) can be controlled with resistant varieties

7. Maize dwarf mosaic virus infection on sorghum causes plants to have:

   a) mottled yellow upper leaves
   b) striped leaves
   c) stalk rot
   d) off-type plants

8. In addition to leaf spots the rice blast fungus also causes

   a) smut
   b) rotten neck
   c) root rot
   d) toxin accumulation

9. Seedling disease of cotton is caused primarily by:

   a) bacteria
   b) nematodes
   c) viruses
   d) fungi

10. Nematode damage on peanuts may be expressed by <u>two</u> of the following symptoms:

   a) speckling of pods
   b) drying up of pods
   c) knots or galls on pods
   d) curling of upper leaves

# FRUIT AND VEGETABLE PEST CONTROL - INSECTS

This section discusses the arthropod pests of fruits, nuts and vegetables. Some of the pests can be found on more than one of these groups of crops. But for convenience, the pests for each crop group will be discussed separately. The life cycle, identification, damage and control practices are emphasized in this program.

## Fruit insects

Tree fruits in Texas consist of citrus, peaches and plums with smaller acreages of apples, pears and other fruits. The consistent stable environment of an orchard can create and maintain many insect problems. Cultural practices within an orchard can sometimes eliminate the insect pests.

Peaches and plums in Texas have a full compliment of insect pests. These pests usually cause a confusing array of pest problems; thus control recommendations for tree fruits have been based traditionally on a spray calendar. This calendar consists of routinely set stages of crop development or plant phenology when sprays are applied as a preventive measure against all insects. Current research may allow us to attack individual pest problems and eventually eliminate some of the sprays from the standard spray calendar.

*Catfacing insects* are one group of major pests attacking fruits in Texas. The conspicuous deformity caused directly to the fruit gives them their name. This damage is caused by penetrating the fruit with their sucking mouthparts. These insects are plant bugs and stinkbugs which suck sap directly from the fruit. Early in the season at the pink bud stage, lygus bugs attack peaches. These insects are about 1/5 of an inch long and range from shades of brown to tan to nearly black. They damage buds, blossoms and small fruits. Populations decline shortly after petal fall as they are attracted to other host plants out of the orchard.

*Stinkbugs* are robust, brown or green insects with sucking mouthparts and usually appear to be 5 sided. Several species attack peaches and plums in this state. The little green stinkbug usually is present in the orchard from petal fall to 2 weeks after shuck split. This is followed closely by another species, the brown stinkbug and later the green stinkbug. All these insects cause catfacing damage by piercing fruit during feeding. This damage may occur early in the fruit's development but the blemishes remain on the final product.

The *plum curculio* is a weevil which attacks peaches and plums. Adult weevils overwinter in wood lots, fence rows and ground debris and move into orchards where they can feed on the fruit. They penetrate the fruit with their snouts and oviposit or lay eggs directly in the fruit. Adult feeding causes some damage but the worst damage is caused by grubs feeding inside the fruit. Larvae tunnel through the fruit as they feed causing considerable destruction. After completing their development, they drop to the ground where they pupate and develop into adults. Two or three generations of this pest can be produced in a single season. If you suspect plum curculio, one of the key things to look for is a characteristic C-shaped crescent on a peach or plum. This scar is formed by the female during the egg-laying process and is a sure sign that plum curculio

is present in an orchard. Spray applications for this pest begin about the time adult weevils leave their hibernating quarters and enter the orchard. This time may vary from year to year, but beetles usually appear in plums during the petal fall stage and in peaches at the time of shuck split.

Two small moths, the *Oriental fruit moth* and the *codling moth*, attack deciduous fruits in Texas. The Oriental fruit moth can be found on peaches and plums as well as apples and pears. This pest usually is found only in the eastern part of Texas. Larvae are the stage that overwinters in a cocoon under the bark of trees. These larvae feed on buds or succulent new growth in the terminals. Later in the summer, successive generations attack the fruit directly when no succulent foliage is available. Several generations of this pest can be found in a single year. Recent advances with pheromone traps allow the capture of adult moths. Thus the egg-laying time of the Oriental fruit moth can be predicted.

The *codling moth* behaves very similarly to the Oriental fruit moth, but it attacks apples and pears. This insect attacks the fruit more directly and causes fruit to drop early in the season. Larvae of later generations are found inside the fruit. Entry holes of the larvae often can be detected at the calyx end of the fruit by a mass of frass or dirt where the larvae enter. Once inside the fruit, the larvae are very well protected from any insecticide application. This again emphasizes the importance of spray timing.

Several boring insects exist such as the *peach twig borer*, the *lesser peach tree borer* and the *American plum borer* which attack the wood of trees. Larvae of these insects attack the trunk, branches or small twigs. Adults are small, clear-winged moths, consequently the larvae are caterpillars which bore into the wood. Spray controls designed for other insects often control these wood borers; however, cultural practices such as removing infested wood from the trees and destroying it are very effective in reducing these pests within an orchard.

Citrus insects and mites

The mites are a common minute pest in citrus as well as in other fruit. The citrus rust mite is the number one pest on citrus in Texas. Rust mites unlike other spider mites, prefer cool, moist weather conditions. Texas citrus and false spider mites reproduce in tremendous numbers especially in hot dry weather. The spider mites damage causes a general bronzing or yellowing of the leaves.

Spider mites are not insects and are actually more closely related to spiders. Because of this, mites are relatively unaffected by many common insecticides. It is usually necessary to select special compounds called miticides for good mite control.

Scales are small sucking insects which can occur in tremendous numbers. Scales are classed as soft scales with no covering and armored scales which have a protective cover over them. The protective cover of the armored scales make them difficult to control without carefully timing sprays. Spray control programs with a dormant oil often are aimed at the overwintering population. Other effective sprays are timed carefully to kill the crawlers or newly hatched nymphs before they find a new site and form a protective coat.

Several kinds of scales can attack nearly every fruit. Scales are a key pest in most citrus production. Species attacking Texas citrus include brown soft scale, Florida red scale, chaff scale, purple scale and others. Oil sprays are sometimes quite phytotoxic to citrus under some conditions thus complicating scale control.

The citrus blackfly is a sucking insect which attaches to the underside of citrus leaves as it feeds. This pest has recently become a concern in Texas and may become a major pest in the future. Presently, biological control programs are helping contain this insect.

Shown below is a chart listing the various insects and mites that attack citrus, where they are found, damage and characteristics of immatures and adults:

CITRUS PESTS

| INSECTS | WHERE FOUND | DAMAGED CAUSED | CHARACTERS | |
|---|---|---|---|---|
| | | | IMMATURES | ADULTS |
| Citrus Rust Mite | Leaves & Fruit | Punct. epidermal cells causing russeting late or silvering early. Small stunted fruit. | Like adult but lighter in color | Wedge shaped, lemon yellow 2 pr. legs. |
| Texas Citrus Mite | Upper surface of leaves along rib. | Sandblasted or silvering of leaves | 6 legs larvae, deuto-nymph 8 legs | Brown-mottled green. |
| Florida Red Scale | Leaves & Fruit | Disfigure fruit. Heavy infestation devitalize tree and defoliation. Young leaves will be distorted. | Yellow crawlers. | Armored. ♀ circular, has nipple, dark red or black shell. Body is lemon yellow, ♂ wing. |
| California Red Scale | Fruit & Leaves | Suck sap from leaves. Serious pest of young citrus. | Lemon yellow first stage. Shell first formed has white cap. | Has nipple, light orange. Armored. |
| Chaff Scale | Leaves & Twigs | Causes degreening in fruit. | Purple | Chaff colored & brownish in color. Lays eggs. ♀ body under shell purple. |
| Brown Soft Scale | Leaves & Twigs Singley & Large Number. | Secretes honeydew, causing sooty mold. | Pale yellow crawlers born alive. | Unarmored, light brown, flat & oval. Wax secreted from skin. |

Pecan insects

*Pecan phylloxera* is a small, soft-bodied sucking insect. This pest passes the winter in the egg stage in bark crevices on the tree. In spring the tiny nymphs emerge and feed on tender leaves or stems. The plant reacts to phylloxera feeding by producing a gall around the insect. Galls appear on leaves or stems. Once inside the gall, it is very difficult to control phylloxera with normal chemical sprays. Recommended dormant oil sprays are directed at the phylloxera eggs in early spring.

The *pecan nut casebearer* is a key pecan pest in Texas. This insect spends the winter as partially grown larvae or caterpillars in a small cocoon called a hibernaculum. After the pecan buds open, the caterpillar feeds on the buds and later moves to shoots. Burrowing of these larvae in spring pecan shoots causes a "flagging" of some terminal growth on the trees which indicates that pecan nut casebearer is present.

A small gray moth emerges as the adult casebearer in late April and May in Texas. Adults are capable fliers and prodigious egg producers, depositing eggs of the first generation in the tips of nutlets in the trees. Careful inspection of the nutlets for eggs allows us to time a spray for this pest at the newly hatched larvae. These larvae feed on new nutlets and can damage all nuts in a nutlet cluster.

A second generation occurs later in the season with adult moths flying in June and early July. This generation also may need controlling by a carefully timed spray after the egg-laying period. A scouting program helps monitor the egg-laying time exactly.

A third or fourth generation may be produced later in the season. However, these larvae are out so late in the season that the pecan shells have hardened and damage is limited. Control measures are not needed for these later generations.

An alternate method for timing sprays for pecan nut casebearer is based on monitoring adult emergence by collecting pupae. Pupae are collected by banding tree limbs with corrugated cardboard under which the larvae pupate. An Extension publication is available on this technique.

Aphids are small soft-bodied insects which suck sap from the leaves of pecan trees. Pecans have a *yellow pecan aphid* and a *black pecan aphid* which obviously are distinguishable by their color. Both winged and wingless forms of these aphids can be found in pecans through most of the growing season. Aphids produce a waxy or sticky substance called honeydew which collects on leaves. Aphids develop very rapidly and both of these species have numerous generations in a single year. Aphids, however, are generally controlled by natural enemies and do not normally reach sufficient numbers to cause serious injury to pecans. Spray controls are seldom advisable for these pests, and in many instances, aphid populations increase after spraying because the spray controls the natural enemies of the aphids. Feeding of the black pecan aphids causes yellowish or necrotic areas in the leaves around the feeding areas. This is due to a substance which the aphid emits into the leaf. The spots may turn brown and some leaves may be shed.

The *pecan weevil* is a brown weevil about 3/8 inch long. The long snout allows the adults to chew a hole through hardened pecan shells. Adult females lay eggs directly in a pecan after making a hole with the long snout.

Grubs that hatch inside the pecans develop rapidly as they feed inside the nut. When the nuts drop to the ground in the fall, the grubs gnaw a hole about 1/8 inch in diameter through the pecan shell. Grubs crawl through the hole and burrow their way several inches into the soil, then form an earthen cell around them.

Weevil development slows down drastically at that time. It takes 2 or 3 years before the adult weevil emerges again and attacks nuts. This year's weevils will produce the ones you see 2 years from now. This is confusing since heavy populations may alternate years. The 2 years are spent as full grown larvae, pupae and adults in the soil.

Control measures for the pecan weevil are aimed at controlling the adults before they lay eggs in the nuts. Base the decision to spray for adults on the number of weevils present and the stage of nut development. To discover adult weevils place a sheet under the tree and jar limbs, causing the weevils to fall on the sheet. Cages also can be used to detect weevil emergence from the soil. Nuts must be in the soft dough stage for weevil development to be successful. Consider this information before spray controls are applied.

The *hickory shuckworm* is another small moth which attacks pecans. The larvae overwinter in fallen pecan or hickory shucks and complete development to adult moths early in the spring. Eggs are deposited on leaves or young nuts in early summer. As many as 5 generations of this insect complete their life cycle within a single year.

Larvae are the feeding stage, and in the early season, they may feed directly in the nutlets. When the nuts have hardened, the larvae only penetrate the shuck. White larvae with a brown head can be found in infested shucks throughout the winter as they lay on the ground. Infested shucks tend to cling to the nuts causing harvest problems. Chemical controls for hickory shuckworm are aimed at reducing the immediate damage to nuts as they mature. Thus, spray programs begin in mid-August.

Hickory shuckworm populations can be reduced significantly by good cultural practices. Removing shucks from under trees or plowing under infested shucks in July and August can slow this pest. Larvae cannot mature in decaying shucks and adults cannot emerge from the soil.

Several types of caterpillars feed on pecans, including the *fall webworm, walnut caterpillar* and *pecan catacola*. The fall webworm is conspicuous because it forms conspicuous webs or tents in the branches once in the spring and again in the fall. Early detection of these caterpillars is important because the later stages do most of the feeding. Early detection methods and prompt spraying are effective control means for these foliage feeding insects.

Several other insects which can also attack pecans include *stink bugs, pecan leaf casebearer, leaf miners, sawflies, May beetles, pecan bud moth, twig girdlers* and several forms of borers. These insects are occasional pests of pecans and often are controlled by sprays directed at other pests.

## Vegetable insects

Vegetable crops in Texas are mostly annuals and therefore highly variable in acreage and rotation from 1 year to the next. Insects respond to this by being either opportunists which develop very rapidly when a crop is available or generalists that feed on whatever is available.

Vegetable insects include a wide variety of creatures and host plants which make vegetable insect control difficult. Also, commercial vegetables are expected to be completely unblemished by the consumer. This means that most vegetable insect control programs are preventive to insure damage-free and insect-free crops. Some insects which do not directly affect the part of the plant used as food are controlled only as needed.

Vegetable insects generally are grouped into 3 main categories--soil insects, sucking insects and chewing insects.

## Soil insects

Soil insects usually attack the seeds at planting time or small tender plants. However, they may attack larger plants of root crops such as carrots, beets or potatoes. Insects in this group include wireworms, cutworms, white grubs, mole crickets and various maggots or fly larvae.

*Wireworms* are click beetle larvae. They are cylindrical, brownish to yellowish and rather hard-bodied. These insects damage seeds, cut into small shoots and often bore into stems, roots and tubers. They attack many plants including potatoes, onions, corn, carrots, peas, beans and melons.

*Cutworms* are the larval or immature forms of certain moths and often cause extensive plant damage. Cutworms are night feeders and seldom are seen during the day. These insects cut off small plants at or near the ground level and feed on the tender stem. Many plants are attacked by cutworms, but they are especially damaging to tomatoes, pepper and corn.

*White grubs* or grubworms are curve-bodied larvae with brown heads. They are immature May beetles or June bugs. They stay in the soil and feed on roots of corn, beans, peas and other vegetables. Damage will be observed as stunted or dying plants usually in spots within a field. Grassy fields and fields which had sod the previous year are often attacked.

*Mole crickets* are velvety brown with strong front legs for digging. They feed on tubers, roots and underground stems. Occasionally, they eat fruit in contact with the ground. They damage peanuts, strawberries, potatoes and other vegetable crops. They can be detected by subterranean tunnels along the soil surface.

*Seed corn maggots* are the white larvae of a small fly. They develop in the soil and feed on seeds and seedlings of corn, beans, peas, potatoes, cabbage, turnips and other crops. Damage may be confused with poor germination or a seedling disease.

The *cabbage maggot* is also the larvae of a small fly. It feeds on the surface of roots and tunnels into them. It attacks cabbage, broccoli, turnips,

beets and similar crops. Other maggots attacking vegetable crops are the sugar-beet root maggot, carrot rust fly and the onion maggot. Damage caused by these maggots is similar to the damage done by different maggots depending on the crop.

*Slugs* and *snails* often damage vegetable gardens. They feed on tender vegetation and can cause serious damage to young, tender plants such as lettuce. Slugs are attracted to beer placed in small containers throughout the garden and may be controlled in this manner. Slug baits are available and are effective if directions are followed. Slugs are not insects but close relatives of snails. Most common insecticides do a poor job of controlling these pests.

*Sowbugs*, often called pillbugs, are not insects but are closely related to shrimp and crabs. Sowbugs, about 3/8 inch long when fully grown, are grayish to black and have seven pairs of legs. They are distinctly segmented, and some species roll up into a ball. They feed on young, tender vegetation or fruit and can damage beans, lettuce, strawberries and other crops. Apply treatment for this pest only when damage appears.

Three main methods are used in soil insect control:

- *Preplant soil application*--Control most soil insects by treating the soil 2 weeks before planting.
- *Bait*--Cutworms and sowbugs can be controlled effectively with bait.
- *Seed treatment*--Rootworms and grub control often is successful by treating seeds before planting.

Sucking insects

Sucking insects have mouthparts for piercing and sucking. They damage plants by inserting their mouthparts into plant tissue and removing plant juices. Heavily infested plants are yellowish, wilted, deformed or stunted and may die eventually. Some sucking insects inject toxic materials into the plant while feeding and some transmit disease organisms.

*Aphids*, often called plant lice, are small, soft-bodied insects ranging from black to green to yellow. They can transmit several diseases. Aphids often occur in extremely large numbers and may cover the entire surface of a leaf or stem. Apply treatments when colonies of aphids appear on foliage.

Several species of *leafhoppers* attack garden crops. They are small wedge-shaped insects which suck plant juices causing yellowing, leaf curling and stunting. They also transmit several disease organisms. Apply treatment when leafhoppers are present on the plants.

*Stinkbugs* are very common insects. The most common species attacking gardens are the green stinkbug, spined stinkbug and harlequin bug. These insects feed on the fruit of many plants, including beets, beans, peas, squash, tomatoes and corn. The harlequin bug also readily attacks cabbage, broccoli and related plants. The fruit and plants shrivel and become deformed. Apply treatment when the first damage signs appear and stinkbugs are still present.

Mature *squash bugs* are about 1 inch long and gray-black in color. Immature bugs are brightly colored with red, green and black. Squash bugs suck juice

from leaves and stems of squash, pumpkins, melons and related plants. Their feeding causes wilting, and in severe infestations, leaves turn brown and fall off. They often can be controlled in the home garden by hand gathering or trapping them under boards or shingles placed beneath the plants. If an insecticide is used, apply when the bugs first appear on plants.

*Thrips* are minute insects feeding on pollen and tender plant tissue. They rasp the tissue and drain the exuding sap, causing stunted and deformed plants. Thrips are usually a pest of seedling plants but also attack plants in any stage. Apply insecticides when thrips are present and plants show damaged terminal buds and cupping leaves.

*Spider mites* are not insects, but are minute red mites related to ticks and chiggers. They suck juices from the undersides of leaves, causing small discolored areas. A heavy infestation causes leaves and flower buds to shed. Apply treatment when mites appear on the foliage or when leaf discoloration occurs. Usually 2 to 4 applications are needed for control. After 2 applications, inspect the plants and make additional applications only if live mites are found.

Chewing insects

Chewing insects cause more damage to the garden than soil pests or sucking insects. They feed on all plant parts and destroy foliage and fruit. A wide range of chewing insects attacks vegetables; among these are grasshoppers, leaf miners, beetles, weevils and numerous caterpillars.

*Grasshoppers* feed on many plants, including most vegetables. Large numbers can completely strip a plant. Apply control measures when foliage shows visible damage and grasshoppers are present.

*Leaf miners* are the immature form of a small fly. They feed between the upper and lower leaf surfaces, tunneling out the tissue. They attack several plants including spinach, pepper and tomatoes. Apply control measures when mines or trails first appear in the leaves.

*Potato beetles* were once devastating to commercial potatoes and still cause considerable damage. The potato beetle is stout-bodied about 1/2 inch long with yellow and black stripes. Both adults and larvae feed on leaves and can completely strip a plant in a short time. They feed mainly on potatoes, tomatoes and eggplant. Apply control measures when beetles cause visible damage to foliage.

Some of the most annoying pests of vegetables are *flea beetles*. These small beetles have hind legs enlarged for jumping. Some are striped, but most are black, brown or green. They attack numerous plants, chewing holes in the leaves. Flea beetles attack beans, peas, cabbage, carrots, eggplants, turnips, mustard, potatoes and tomatoes. Apply insecticide when tiny holes appear in the foliage and beetles are present.

Both *striped* and *spotted cucumber beetles* attack garden plants. These beetles feed on stems and young leaves soon after the plant emerges. Their larvae often tunnel into plant roots. Adults also feed on blooms and fruit. Plants most

commonly attacked are cucumbers, squash, pumpkins and melons. Apply insecticide when beetles and damage occur.

A number of species of *blister beetles* attack garden crops. They vary greatly in size and color from black to gray to spotted and striped with black and yellow. These insects can strip foliage from plants almost before they are noticed. Also, they secrete a vesicating fluid that causes blisters when it touches the skin. Therefore, avoid or carefully handle these beetles. Apply insecticide when beetles begin moving into the garden.

*Vegetable weevils* attack potatoes, tomatoes, turnips, carrots and many other vegetables. Both adults and larvae feed on the buds, foliage and roots at night. Apply insecticide when weevils are found damaging plants.

Several *armyworms* attack the home garden. Among them are the beet armyworm, fall armyworm and yellow-striped armyworm. They are foliage feeders, very destructive and attack most vegetable crops. Apply control measures when damage and small larvae appear on the plants.

The *corn earworm* also is known as the cotton bollworm, sorghum headworm and tomato fruitworm. It is very devastating to corn and tomatoes and often to cabbage, beans and peppers. Larvae may reach 1½ inches and vary in color from green to pink to almost black. They tunnel into fruit or feed on leaves. The corn earworm usually damages the kernels at the tip of corn ears. Apply control measures when larvae are small. Sprays on corn can be timed by watching for eggs on silk.

The *cabbage looper* is a light green larva that moves with a looping action. It is often found with the imported cabbageworm feeding on cabbage and related plants. Damage consists of holes eaten in the leaves. Apply insecticide while larvae are small.

*Tomato hornworms* are the most destructive and widespread pest of tomatoes. It is a large, green larva with a hard, curved horn on the back end. A few large larvae can strip a plant rapidly. This pest often can be controlled by handpicking. Apply insecticide when larvae and damage occur.

*Melonworms* and *pickleworms* have somewhat the same habits. Young larvae feed on the foliage; later they mine into the stems and fruit. They can severely damage melons and cucumbers late in the season. Apply treatment at the first sign of damage.

The *beet webworm* and *garden webworm*, in attacking numerous vegetable crops, spin a web on the plant and devour the foliage. The beet webworm is a rather slender yellowish-green larva with a black stripe on the back. The garden webworm is light green to yellow and has blackdots covering the body. Apply treatment when larvae and damage appear on plants.

Cultural practices play a significant role in reducing or eliminating many insect problems in gardens. The following cultural practices aid in controlling insect pests.

. Maintain a clean, closely mowed area adjacent to the garden.
. Dispose of any trash, boards or debris in the area.

- Keep soil at maximum fertility level and well watered.
- If only a few plants are involved, handpick larger insects, crush insect egg masses or wash smaller insects off plants with a waterhose.
- Use cardboard protectors around transplants.
- At the end of the season remove all plants and plant debris.

Follow 3 main steps in spray control practices for vegetables.

- Know the insect conditions in the field.
- Make a decision whether control is needed and when it should be applied.
- Follow recommended control practices.

## REVIEW QUESTIONS

### FRUIT AND VEGETABLE PEST CONTROL--INSECTS

1. The generation of the pecan nut casebearer that generally should be controlled is?

   a) 1st
   b) 2nd
   c) 3rd
   d) 4th

2. Slugs are related closest to:

   a) insects
   b) mites
   c) snails
   d) shrimp

3. Which of the following is *not* another name for the corn earworm?

   a) cotton bollworm
   b) sorghum headworm
   c) tomato fruit worm
   d) eggplant girdler

4. Dormant oil sprays should be applied in:

   a) spring
   b) summer
   c) fall
   d) winter

5. Which aphid causes necrotic areas on leaves of pecans?

   a) yellow pecan aphid
   b) rosy pecan aphid

c) black pecan aphid
d) oat-bird cherry aphid

6. Which of the following is *not* a soil insect in vegetables:

a) cutworms
b) vegetable weevil
c) wireworm
d) seed corn maggot

7. The Colorado potato beetle adult is:

a) long and slender
b) red with black spots
c) yellow and black striped
d) a variety of colors depending on background

8. A key to determining if plum curculio is attacking fruit is:

a) bronzed leaves
b) a C-shaped crescent scar
c) flagging terminal branches
d) drips falling from the leaves

9. Catfacing insects include lygus bugs and

a) stink bugs
b) squash bugs
c) pecan weevil
d) feline bugs

10. What kind of mouthparts do scales have?

a) chewing
b) sucking
c) rasping
d) both b and c

## FRUIT AND VEGETABLE PEST CONTROL - PLANT DISEASES

Peaches have an appealing appearance and protected by pesticides are free of insects and diseases. A great deal of planning and work goes into the production process. As a commercial applicator you must keep fungicides on the crop at certain stages to avoid complete crop loss. These stages become evident when studying the development of individual diseases.

Peach leaf curl is the first disease to hit peaches in the spring. It is a fungal disease and the spores overwinter on the bud scales. As young leaves emerge in the spring, infection takes place. This does not occur every year, but is dependent upon weather conditions. Periods of light rains and cool temperatures favor development of this disease. If one of these conditions is not met, leaf curl is not a problem. To control leaf curl, a fall spray program using one of the copper-type fungicides must be followed.

Brown rot of peach is another early disease even though many people think of it more on mature fruit. It attacks young blossoms causing a twig blight. Symptoms of brown rot are more obvious on fruit that turns brown and decays rapidly. The rotting action is very rapid under $75^{o}$ to $80^{o}$ temperatures. Under cold storage conditions, this can be reduced greatly; however, complete crop loss occurs if steps are not taken before bringing fruit to the packing shed.

The brown rot fungus causes a canker when it enters the blossom, and this serves as a means of the spring infection.

By opening the canker one can see the fungus has developed down into the wood of the tree. It causes a girdling, and complete loss of any fruit leaves occurs beyond this canker.

Do not confuse Rhizopus rot with brown rot. Rhizopus rot has a much more whiskery-type growth and is more of a problem on the fruit after it has been picked and brought into the warehouse for handling. Many fungicides used for brown rot control also control Rhizopus rot.

Peach scab is a fungal disease of peaches that causes a freckling of the fruit. This infection occurs in the very early growth stages of the peach; however, it takes 21 days from the time the infection occurs before spots are visible. Peach scab can be controlled with fungicides, but applications must be applied early. One must spray before spots form. Applications must begin very early in the life of a fruit and continue until picking.

Consider some of the more active materials now on the market if peach scab is a problem.

Bacterial leaf spot often is confused with peach scab; however, it is completely different. Bacterial leaf spot causes a much deeper lesion and in most cases a more angular-type lesion than scab, which is more circular.

Bacterial leaf spot attacks the foliage and fruit of the tree. Control for this is based on a fall spray program using one of the copper fungicides just at leaf drop. Although several materials have been used during the growing season, these have not proven completely satisfactory. Also in bacterial leaf spot control, use of resistant varieties has proven very helpful in eliminating much of the losses.

Peach rust is a problem that attacks trees, particularly from a line south of Waco, in the latter part of the summer and early fall. This is a fungus which causes severe defoliation of the peach trees in these areas. It represents a major limiting factor in peach production in South Texas. Peach rust causes the orange pustules seen on the lower side of the leaf. When rubbing a finger across these, orange spore material will be visible. This is wind blown to other trees, and eventually other infection takes place.

The upper side of the leaf is marked by distinct yellow spots. Peach rust is a problem and must be controlled on peaches throughout the southern part of Texas, if peaches are to be grown commercially.

Leaves marked by a flow of gum from around the internodes of the twigs may signal development of bacterial canker. This results when a bacterial disease builds up pressure within the tree and forces the gum to flow out around these areas. Bacterial canker is a disease that causes severe loss of trees in Texas. Loss from this disease occurs over a 2- to 3-year period. Nothing can be done once a tree becomes infected other than give the tree the best care possible. This involves pruning, fertilizing and irrigating where needed.

Bacterial canker is a vascular wilt of fruit trees. The darkened area is the region infected by bacteria resulting in plugging. This vascular-type problem is very difficult to control as most of the materials on the market are not systemic enough to be active on a disease once the organism gets to this depth.

Crown gall of peaches as well as other woody fruit crops is a serious problem and causes considerable concern among commercial growers. It causes a large, dark-colored gall to form on the roots or trunk. If the crown gall bacterium attacks the trunk, it may completely girdle and kill the tree. If it occurs on the small lateral roots, it may weaken the tree slightly, but will not cause death. Crown gall enters tree tissues through wounds, breaks or epidermis of the root.

Mushroom root rot of peaches is a fungal disease which attacks the tree's root system. It grows up the roots to the trunk of the tree eventually girdling the tree and causing death. Death generally occurs within 2 years after infection is visible. In diagnosing mushroom root rot consider the absence of a living root system on the tree. If the tree is killed by mushroom root rot, the root system will deteriorate to the extent it is no longer attached to the tree. The tree can be moved in the soil, simply by shaking it back and forth. Other root rots will attack peach trees; however, they will not destroy the root system such as mushroom root rot, and trees will not move if shaken vigorously. The white fungal growth under the bark also is a diagnostic tool

used in distinguishing mushroom root rot. A number of things have been tried to control this disease, but none have proven particularly effective. In some cases soil sterilization has been used, but the main problem here is reinfestation of the area once the organism has been controlled.

Root knot nematodes of peaches is a very serious problem. Although a number of nematicides can be used on established trees, the best method of preventing this problem is the use of resistant root stocks. The root stock, Nemaguard, has proven very resistant and should be used on all peach trees grown in Texas.

Not all problems with trees are associated with diseases. Many things may cause unusual symptoms. High rates of herbicides, for example, may cause yellowing of the margins.

Iron chlorosis of peaches is a problem in the more alkaline soils in Texas. If treatment is not applied, trees may become stunted and die.

Spray schedules are available which cover the period when the first peach is seen on the bud until harvest. Follow this spray program if healthy fruit is to be produced. It is very important that each step be considered during the season.

Quite often in literature, reference is made to dormant, pink bud, full bloom and petal fall. This question often arises, "What stages are these?" Learn the different stages which will better explain spray dates and spray schedule utilization.

Plums, another fruit grown commercially in Texas, also grows in many backyards throughout the state. They are a good crop for most homeowners as they require a limited spray program. They can be grown in many of the more southern areas of the state where less chilling occurs. Most plums require approximately 500 chilling hours to bloom. One disease problem on plums is brown rot. This is very similar to the organism that attacks peaches, and control is the same. Like on peaches, it requires a spray program. An intense spray program during the early season is needed to prevent losses from this disease. Another problem on plums is plum rust. It is very similar to peach rust, again giving a dark reddish-brown, powdery material on the lower side of the leaf. Rust on plums occurs from mid-summer into the fall and causes defoliation if not controlled.

Fire blight of pear is a very serious problem. It occurs from early spring into the fall, or at any time the wood is active and growing. Fire blight is a bacterial disease. It develops within the wood and therefore, spraying should be used as a protectant rather than control program. Not only are bearing trees affected by fire blight, but also young seedlings being grown in nurseries. Spray these seedlings to control the problem. Kieffer and Orient varieties have some resistance and should be used only in Texas. Other French-type pears are sold; however, these are extremely susceptible to the problem and control is virtually impossible.

Fabraea leaf spot of pear occurs in the spring and fall during periods of mild temperatures and light rainfall. If a strict fire blight prevention program is used, Fabraea leaf spot also will be controlled with these sprays.

Fabraea leaf spot not only causes loss of foliage on pear trees, but loss of fruit as well. A number of other rots will attack pear fruit just as it reaches maturity. These must be controlled if the fruit is to be kept for any period of time. There are two principal problems--sooty blotch and fly speck--that occur on pears in Texas. Symptoms on apple are very similar or identical to those on pear. Devise and use spray programs in the fall for a healthy, disease-free pear crop.

Black rot of grape is probably the major limiting factor of grape production in all Texas areas. This is a fungal disease which causes foliage loss.

Grapes would simply be eliminated if a control program for black rot were not used. Controlling this disease must begin at the early stages of plant development in spring and be carried out on a 2- to 3-week schedule throughout the season for adequate control.

Pierce's disease is a bacterial disease of grapes. It is carried by a leafhopper and has been found in some areas of Texas. The French varieties of grapes are extremely susceptible to this as well as many of the French-American hybrids. The American grapes such as Black Spanish are resistant to this problem and can be grown in areas where Pierce's disease has been a problem.

Cotton root rot is a problem on most woody perennial fruit crops such as grapes, apples, peaches, and pears. It causes a rapid plant loss. In examining the root system, one finds that the bark sloughs off the wood and in some cases a very fine strand of mycelium develops along the buff brown root. This resembles a small hemp rope wrapped around the bark. This is a diagnostic tool in working with cotton root rot. In addition to fruit trees, shrubs will die rapidly and leaves will remain attached to the tree.

Strawberries are a commercial crop in selected areas. The main disease problem is a loss of fruit to fruit rot. This can be prevented and controlled with fungicides if favored by high rainfall and mild temperatures during the fruiting season. Sprays must be repeated on a 4- to 5-day schedule if the disease is to be controlled.

Leaf spots are numerous on strawberries and have been observed throughout different areas of Texas. Fungal leaf spot causes severe foliage loss and may prevent foliage from obtaining its maximum effectiveness as far as production is concerned. Leaf spot must be controlled if the plant is to have a long and successful production period. Most fungicides currently used in the home garden are effective against this leaf spot.

Apples are important to Texas fruit production. Here we see a disease such as bitter rot occurring on the fruit as it is reaching maturity. It is

important that this disease be controlled, because the fruit is not salable and would be a loss to the grower. The spores penetrate directly through the mature fruit, causing the loss.

Another problem on apples in Texas is black rot. This also attacks the fruit near maturity and causes a rather severe loss. It is important that sprays be used throughout the season, but it is especially important that sprays be applied at and near harvesting to prevent these two problems. In spraying any fruit trees, it is important that the rate of material be controlled very closely. Quite often, less than the recommended rate of material is used and as a result inadequate control results. Consult the label very carefully regarding the amount of water and material recommended when spraying any fruit or nut plants.

Two additional diseases of apples that cause serious quality losses near maturity are sooty blotch and fly speck. These diseases do not cause a lot of damage to the interior of the fruit, but are more superficial in nature. It is important, however, that these be controlled if a crop is to be grown and marketed.

Melanose, a disease of citrus leaves and fruit, affects all citrus, but is more noticeable on grapefruit. Melanose markings on grapefruit consist of small, raised superficial dots or pustules. The pustules may run together affecting large areas of the fruit. When this happens, the fruit feels hard like coarse sandpaper. Sometimes pustules may form a tear-streaking pattern, caused by dew or raindrops flowing over the fruit-carrying spores. Do not confuse melanose symptoms with rust mite damage, which is smooth to the touch.

Greasy spot is another fungus disease of citrus leaves commonly found in Texas orchards. Initially, the spots are yellow and appear on both upper and lower leaf surfaces. Later they turn brown and finally black, appearing slightly raised and greasy. With severe infection, leaves may turn yellow and drop prematurely. Fungal infection is favored by rust mite injury and humid weather.

Foot rot affects fruit and the trunk above and below the ground. The disease is more prevalent during prolonged wet and rainy periods. Symptoms consist of exudation of small or large amounts of gum, depending on the variety and the weather. The dead bark breaks away from the wood at the base of the tree, sloughing off in an irregular pattern. If the lesion encircles the trunk, girdling occurs, killing the tree. Control is best accomplished by placing the buds high on the rootstock, planting citrus in well drained land, not allowing the trees to stand in water, keeping soil away from the trunk and keeping the base of the tree free of weeds, dead leaves and other debris.

Nematodes are microscopic worms that live in the soil and feed in underground parts of the tree. They are so minute that they cannot be seen with the naked eye. Therefore, their presence may go undetected. Nematode damage usually is recognized by its effect on the overall appearance of trees, together with soil sample results collected in the root zone. Symptoms of nematode damage include wilting, lack of vigor, poor fruit production, small

fruit size and poor response to watering and fertilization. When these symptoms are observed, collect a soil sample and send it to a diagnostic laboratory such as the one operated by Texas A&M University at College Station.

When conditions require it, treat by adding up to 4 gallons per acre of DBCP in the irrigation water. Good mixing and proper calibration of equipment are essential for good control.

If peaches are considered the queen of fruit, then pecans must be considered king. Of the nut crops in Texas, it is number one. Pecan scab is a pecan disease that causes a great deal of loss annually. This loss affects the quality and quantity of pecans. Scab infection prevents the pecan from filling properly and also causes the dropping of the nut under severe conditions.

Pecan scab is a fungal disease of pecans. It causes extensive lesions on the pecan. This prevents pecans from filling properly and results in most of the pops.

Pecan scab overwinters in the twig lesion and also in old shucks left in the tree. It is important to start an early season spray program. In many Texas areas where rainfall is above 32 to 33 inches, spraying must be continued on a 2- to 3-week schedule throughout the season for adequate control.

Pecan scab attacks the foliage as well as the nuts of pecan trees. The foliage is not effective in producing food for the pecan tree and as a result will be shed very shortly. This weakens the tree. Pecan scab must be controlled with foliar fungicides. Three to seven applications yearly are required depending upon rainfall.

Sticky shuck is a relatively new pecan disease found in many areas of Texas. This has been associated with a fungus which has now been identified by the research staff at Texas A&M University.

Very black sunken lesions seem to be more constricted in size than scab. In cutting it away, one can see no indication of tunneling as might occur with shuck worm injury. This disease coincides with the water stage of a pecan and sprays must be applied at that time for protection.

Pecans cut open during the water stage have the gelatinous or jelly-like material. From this time until maturity pecans appear susceptible to sticky shuck.

Sticky shuck is not to be confused with true shuck disease. When pecans are opened there is simply nothing in them. This production loss is a result of the natural girdling of the peduncle of the cluster during July. This girdling prevents nutrients from flowing into the pecan causing it to grow undeveloped and abnormal. Because of this pecans will fall 2 to 3 weeks earlier than normal. This disease is a genetic problem related to the variety Success and its offspring. Sticky shuck drop will occur in the first part of August.

Powdery mildew on pecans causes concern to commercial people; however, it does no economic damage. In most cases, if you are following a good pecan scab

spray program, powdery mildew will be controlled. As a side benefit, powdery mildew develops in the upper layer of the shuck and does not have an effect on the movement of nutrients into the pecan which occur in a network of veins between the shuck and the shell tissue.

Downy spot is a foliar disease of pecans that attacks the tree foliage late in the summer. It causes defoliation of some varieties, such as Stuart, if not controlled with fungicides applied in the fall.

Vein spot is a disease that occurs in the early part of the season, just about the same time that pecan scab does. It may cause slight defoliation. It does not cause a lot of concern from most people because of the very minor effect it has on pecan production. If a well rounded pecan scab spray program is carried out, vein spot also will be controlled.

Liver spot is a fungal disease of pecans that causes foliage loss during the late fall. It must be controlled if pecans are to be made on an annual basis. All these diseases such as downy spot, liver spot, vein spot and others can be controlled by well planned spray programs using approved fungicides. They must be used throughout the season. One or two applications in the spring will not give adequate control.

Root knot nematodes on pecans are becoming an increasing problem in Texas. It has been traced back and relates to the nursery industry not only in Texas, but in other areas where these trees are being grown in nematode-infested soil. Work is underway to develop a fumigation program with these people. It is hoped their trees will be in the very near future nematode-free as a result of a fumigation program.

The presence of galls or swelling along the main root is the main symptom. These swellings are indicative of the females that are growing and then developing. Control is simply to watch nursery stock. Select only those which are good and clean; discard any seedlings that show any indication of nematodes.

A program was developed for the Central Texas area and may need modifying for your particular area of the state. In most cases the critical point is around 32 inches of rainfall annually. In areas of higher rainfall, greater pressure is put on the pecans because of higher disease incidence.

Budded pecans are much more susceptible to pecan diseases and also the growers plan to get more production from them. Thus, spray programs are much more intensive to get maximum production. This program, as with the native pecan, must be adopted and modified for each area in Texas.

It is important that a spray program is followed throughout the season if pecans are to be grown year after year.

Pecan spraying is a very important task. It is necessary that sprayers be calibrated very carefully so that one knows exactly how much water and chemical is being applied. To apply less than the recommended amount of chemical to a tree, results in less than adequate control. Also equipment

should be in perfect working condition because of the high foliage density and height of many pecan trees in Texas. Improperly operating equipment will not reach the top of these trees; therefore, it will not give the necessary control.

In disease control of any plants, there are three basic things to consider to prevent a disease epidemic. First, there must be a susceptible host to the disease. Next, the fungus must be present. This usually can be assumed since fungal spores are wind blown. The third point and probably just as important as the other two is the environment. Temperature and humidity are critical factors for disease development. By knowing the environment, one can predict when a disease will be a problem and steps can be taken to alleviate the situation.

Watermelons cover many of the vegetable acres in Texas. Gummy stem blight attacks watermelons, cantaloupes and some of the other vine crops. It can be controlled with foliar sprays of approved fungicides. Begin these applications when plants start to run. Continue at 2- to 3-week intervals throughout the season. Gummy stem blight is caused by a fungus. It is wind blown from one plant to another. Washing of the soil also carries the fungus through the field.

Anthracnose on watermelons is serious in Texas as well as downy mildew. Downy mildew is somewhat darker in nature and has larger lesions than anthracnose. Both of these diseases can cause severe losses. When weather conditions favor disease development, complete crops can be lost in 24 to 48 hours, if steps are not taken to control it. Use approved fungicides on a preventive program during these disease periods.

Fusarium wilt of watermelons has become more and more of a problem. Use of resistant varieties has been the way to go; however, many earlier varieties thought to be resistant are now susceptible. Charleson Gray is still one of the better varieties; others are Calhoun Gray and Louisiana Queen.

Cabbage is the number one vegetable crop in Texas acreage-wise. Texas ranks nationally among the leaders in cabbage production. One problem in raising cabbage is the presence of black rot. This is a bacterial disease which causes severe losses. The bacteria enters through the lenticels at the margins of the leaves and develops downward into the leaf. This causes a yellowing and eventually death of the plant. Select seeds treated with hot water and practice a thorough rotation program. Once the leaf decomposes in the soil, the bacteria break down within 6 to 7 months. By waiting an additional year, cabbage can be regrown in that area with some success. Much of the black rot spreads on infected seeds.

Downy mildew of cabbage causes a black spotting on the head. This can cause severe losses in cabbage and if not controlled causes complete crop loss. Downy mildew can be controlled with foliar fungicides; however, applications must begin at the first sign of disease and continue at 2- to 3-week intervals for three applications. Cabbage is difficult to spray because of the nature of the leaves and for that reason, exercise care in applying fungicides to get adequate coverage.

Alternaria leaf spot of cabbage is becoming more of a problem, particularly on cabbage grown in the early fall and receiving an early freeze. It is felt that the freeze damages the leaves. As a result, the leaf spot comes in the foliage and reduces the quality of the head below USDA number one standards. Control Alternaria leaf spot with an approved fungicide, but applications must begin early before the crop is severely damaged.

Internal tip burn of cabbage is a nutritional problem, related to the calcium nutrition of the plant. Certain varieties such as Green Boy seem more susceptible to this disease than varieties such as Market Prize or Gourmet. Control can be achieved by growing varieties resistant to this condition. No disease organism is associated with it. It is sometimes confused with downy mildew.

Carrots rank among one of the leading vegetable crops grown in Texas. They are subject to a number of leaf blights such as Alternaria and Cercospora. These diseases can be controlled with foliar fungicides, but applications must begin at the first sign of disease and continue at 2- to 3-week intervals during the season.

Nematodes are very important on all vegetable crops, with carrots being especially susceptible. Using a nematicide is the best method of preventing this problem. Where there is a history of nematodes, fumigate the land before planting. Carefully apply this material. Read the label and follow the waiting period so that root injury or plant toxicity will not occur.

Tip blight of onions is a disease caused by what is felt to be one of the Alternaria species. It causes considerable loss on onions during periods of high humidity and mild temperature. The fungus attacks the foliage, causes a collapse of the tissue and, in severe cases, penetrates down into the bulb of the onion causing decay and loss.

Onion varieties vary considerably in their susceptibility to tip burn. Using resistant varieties along with foliar fungicides are the best methods of preventing this problem.

Purple blotch is another serious disease of onions. It is very similar to tip blight and causes foliage loss and reduces yield by causing bulb deterioration. Foliar fungicides applied on a regular basis prevents this problem. Presence of tip blight or purple blotch is directly related to the number of hours the foliage is wet. The disease increases the longer the foliage is wet.

Cantaloupes continue to be an important crop in Texas, but they have many disease problems. One of these is powdery mildew. Powdery mildew not only affects cantaloupes, but also squash, watermelons and many other vegetable crops grown in the home garden and the commercial field. Use fungicides only if resistant varieties are not available. Apply fungicides on a regular basis.

Downy mildew, a very severe problem on cantaloupes, is a problem during high rainfall causing complete loss within 24 to 48 hours after infection

occurs. Fungicides can be used, but they must be applied as a preventive program before the disease begins to show up. Close watch of weather conditions helps assure proper timing of fungicide applications.

Tomatoes are grown in a limited acreage over the state. Greenhouse tomatoes are particularly susceptible to leaf mold. This disease is severe on tomatoes and must be controlled with weekly sprays of approved fungicides covering both sides of the leaf.

Field tomatoes are subject to a number of leaf spots. One is known as Stemphylium or gray leaf spot. This disease affects foliage and results in the much reduced tomato size and quality. Apply foliage fungicides if the tomatoes are to be raised as a commercial crop.

Soil rot of tomatoes is serious in Texas. Fruit grown near the soil invariably will be lost from attacks of soil rot organisms. This can be reduced by applying fungicides. It is important to keep fruit off the ground to prevent spores from splashing up with water and infecting the tomatoes. Irrigation of tomatoes also causes this, as it wets the soil and develops an environment conducive to disease development.

Tomatoes and commercial vegetables are subject to a number of viruses. Tobacco mosaic virus is transmitted by handling virus-infected plants and then going to a healthy plant. People handling plants should wash their hands before handling healthy plants.

Fusarium wilt on tomatoes is a soil-borne problem. It is caused by a fungus that infects the root system causing a plugging of the vascular system. Plugging causes the plant to wilt for approximately 1 to 3 days and then die.

Peppers are an economic crop in Texas. Many viruses affect peppers creating a very serious problem. Five viruses affect peppers and cause stunting and reduced yields. These viruses must be prevented if peppers are to be grown satisfactorily. Use of resistant varieties provides protection from some of the viruses, but this will not completely eliminate the virus problem. Insect control should be practiced. Do not walk in fields while wet; remove any virus-infected plants from the field as soon as they are observed.

A number of leaf spots, both fungal and bacterial, affect peppers causing severe foliage loss during the year. This foliage loss can completely kill the plants during some seasons. Begin fungicides and bactericide applications at the first sign of disease or at the time the fruit begins to set and weather conditions are favorable for disease development.

Good coverage is essential for good control. The material must be on the plants when conditions are favorable for disease development; continue applications during favorable weather conditions. Personnel using chemicals should watch the rates and doses very carefully to insure ample coverage for adequate control.

There are basically five reasons why it is necessary to continue applications:

1. Plants continue to grow and new untreated leaf tissue must be protected from disease.

2. Different diseases appear at different times. Diseases may occur early, late or throughout the season. So, with a single spraying, certain diseases may be missed.

3. *Materials break down.* Most of the fungicides used in commercial plantings have a residual of around 10 to 14 days. Therefore, anything that comes in after that 14-day period will not be controlled by the fungicide. This breakdown may be due to sunlight and organic acids present on the leaves. Ultraviolet rays from the sunlight are very active in breaking down chemicals.

4. *Rainfall.* Chemicals erode from the leaf surface by rain. This continues to reduce the amount available on the leaf for killing any fungi.

5. *Heavy dews* break these materials down. They also aid in distributing the fungicide. Disease control in fruit, nut, and vegetable planting is an important part of production and must be done. As indicated earlier, a great deal of disease control planning must go into producing any crop, whether it be peaches or onions.

## REVIEW QUESTIONS

### FRUIT AND VEGETABLE PEST CONTROL--PLANT DISEASES

1. Peach leaf curl occurs:

   a) early in the season
   b) mid season
   c) late season
   d) causes limb swelling in winter

2. Rhizopus rot is a storage disease of peach that can be identified by:

   a) deep sunken lesions
   b) whiskery type of fungal growth
   c) spots on skin of peach
   d) drying up of fruit

3. The root knot nematode causes the following symptoms on peach:

   a) crown gall
   b) mushroom root rot
   c) knots on roots
   d) a vascular wilt

4. The major disease limiting grape production is:

   a) iron chlorosis
   b) black rot

c ) Pierce's disease
d ) wilt virus

5. Pecan scab causes nuts:

a ) not to form
b ) be dwarfed and mis-shaped
c ) fill poorly
d ) turn purple

6. Pecan scab:

a) can be controlled with fungicides
b) cannot be controlled with fungicides
c) can be prevented by controlling insects
d) can be controlled by letting natural enemies increase

7. Fusarium wilt of watermelons can be controlled by:

a ) using foliar fungicides
b ) using resistant varieties
c ) lowering the soil pH
d ) late planting

8. The most severe disease of cabbage is:

a ) black rot
b ) anthracnose
c ) scab
d ) wet rot

9. Powdery and downy mildew of cantaloupe:

a) can be controlled with the same fungicides
b) are really the same disease
c) can be controlled with properly selected fungicides
d) cannot be controlled chemically

10. The need for repeated sprays with fungicides is dictated by *all but one* of the following:

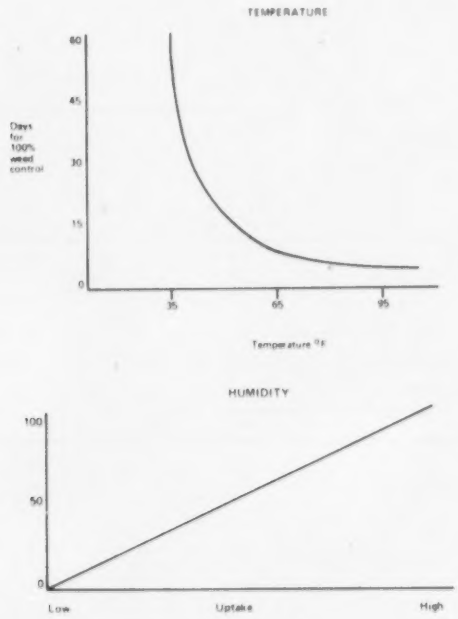
a) plants continue to grow new leaves
b) disease organisms continue to infect
c) fungicides break down
d) insect populations keep the disease going

# WEED CONTROL – CROPLANDS

A weed is any plant that is a hazard, nuisance or causes injury to man, animal or desired crop. Johnsongrass is a weed in grain sorghum.

## Climate and soil

Climate and soil affect chemical weed control. The warm season rainfall in Texas ranges from 8 inches at El Paso to 28 inches at Orange. In low rainfall areas, lower rates of soil-applied herbicides are used for weed control. In high rainfall areas, higher rates of herbicides usually are needed with more treatments to give full season weed control. Herbicides may leach into the plant bed and break down more rapidly in higher rainfall areas. Also, weed intensity is greater.




Herbicides applied to weed foliage after emergence are absorbed poorly when the humidity is low, but uptake of the herbicide increases with higher humidity. In low humidity areas, such as far West Texas, the High Plains and Central Texas, extra surfactants are usually added to improve leaf absorption of certain herbicides. In the Texas High Plains, nonphytotoxic oils are frequently used, but on the Coastal Plains surfactants or oils may not be used when spraying. The surfactant reduces surface tension, and the spray droplet spreads on the leaf for better absorption. Without a surfactant, the spray droplet beads up and absorption is poor. Surfactants are not used with all herbicides; use them only if the product label specifies additional surfactant. Temperature influences the quickness of effect from some herbicide treatment.

Soil texture, which consists of clay, silt and sand, influences the use of herbicides. The herbicide moves through the soil profile and is absorbed on clay particles. Thus, it is tied up like a magnet and will not continue moving through the soil profile.

Another soil factor influencing herbicide use is organic matter, which has many sites to tie up a herbicide. As the herbicide moves through the soil, it is tied up by orgnaic matter and remains near the soil surface. For example, water, herbicides, sodium, calcium and ammonia are tied up by organic matter. The herbicide molecule moves past the smooth sand surface deeper into the soil profile. Leachability of a herbicide is dependent upon the attraction between the organic matter and the herbicide, the solubility of the herbicide in the soil suspension and the amount of water passing through the soil profile.

By understanding soil and climate factors across Texas, one realizes that heavy soils containing clay and organic matter require more herbicide for weed control than a medium or coarse soil.

Diuron and atrazine leach deeper into a Collins silt loam (low clay and organic matter) than in a Bowdre clay loam (high clay and organic matter) under 3 inches of simulated rainfall, but atrazine leaches deeper than diuron in both soils.

An applicator should avoid crop injury caused by poor tank agitation after stopping the equipment for lunch or a break. After the tank is reagitated, the herbicide is safe to the crop.

An overtreated area in a field may carry over into the next crop and prevent a stand. Keep records on all fields treated with herbicides and mark mistakes where possible.

Weed development and competition

Important factors in weed control are weed development and competition with crops. Stages of weed development are seed, seedling, vegetative, flowering and mature.

Seeds of different weeds have a specific shape, color and size. Mature weed seeds are viable and capable of multiplying in abundance. Crabgrass, morningglory, pigweed and Johnsongrass are warm season weeds. Crabgrass, morningglory and pigweed (carelessweed) are annuals; Johnsongrass is a perennial.

Pigweed, as an example, is discussed for its development and competition. Remember the small, numerous black seeds. Studies on the High Plains show that four pigweed in 32 feet of row can reduce grain sorghum yield by 600 pounds per acre.

Pigweed seed germination was recorded in a field of moist Miller clay soil in Burleson County, Texas. From April 1 to 15, over 400 thousand pigweed seedlings per acre were recorded. The field was cultivated to kill the pigweed stand. A new stand was counted or May 3 and over 96 thousand seedlings per acre were recorded for a grand total of over one-half million seedlings. Soils in fields throughout Texas are infested with viable weed seeds which are ready to become established under favorable conditions. When these weeds are not controlled chemically or mechanically, they severely reduce crop production.

The root profiles of both grain sorghum and pigweed were studied. Grain sorghum roots extended 7 feet on each side of the row and to a depth of five feet. The root of pigweed extended 6 feet on either side of the row, and grew to a depth of 8 feet.

Few perennial weeds in crops can match field bindweed for vigorous growth. It is the most fearsome perennial weed in the Texas High Plains. It can spread up to 20 feet in diameter annually, and the seeds can live in the soil for 50 years. Field bindweed has been the target for control in weed control districts in the High Plains for years. The hormone-type herbicides translocate into field bindweed rhizomes. Examples are picloram and 2,4-D. The organic phosphonate, glyphosate, is readily absorbed by field bindweed.

It is easy to see how bindweed can ruin cropland when one considers research results which found that underground roots of field bindweed may total 1,200 pounds per acre. Seven hundred and eighty four pounds or 62 percent of the roots occupy the top foot of soil and 14 percent are in the second foot. The roots continue past the 6-foot mark and a few have been found at 8½ feet.

Weed control methods

Weed control methods include (1) mechanical, (2) chemical (preplant - before planting, preemergence - before emergence of the crop and weed, or postemergence - after the weed has emerged) and (3) combination of methods.

Preplant herbicides are applied on a clodless, crop residue-free surface when the soil surface is moist but not wet. Make uniform applications without overlapping.

Soil incorporation by disking or power driven tools is essential for weed control with preplant incorporated herbicides. It should be thorough and uniform. The incorporation implement should follow the sprayer to avoid chemical loss caused by environmental factors of light, wind and temperature. Incorporated herbicides are used in certain vegetables, pecans, citrus, soybeans, cotton, corn, peanuts and forage legumes.

Preemergence herbicides are applied after planting the crop. Applications should be uniform, either broadcast or in bands over the crop row. Adjust the equipment close to the ground to minimize spray drift during windy conditions. The soil should be free of crop residue and the plant bed should be firm and moist. The top of the bed should be as level as possible and without a deep planter furrow.

A preemergence herbicide is applied for weed control in rice as directed on the label. The wind speed should be at a level to allow the herbicide spray swath to stay in place and not drift to adjoining areas. Bifenox controls the weedy grass, sprangletop, which is not controlled with propanil.

In citrus, herbicides are applied with equipment that shields the nozzles and lifts the lower limbs to avoid spray contact on stems and limbs. The soil should be weed free and in good condition for uniform preemergence application. Tree rows should be in line and evenly spaced for easy adjustment of the equipment for a down and back trip per middle space. In citrus, the application of persistent herbicides should not be applied around young trees. This type of sprayer would also be useful for herbicide application in peach, pecan plantings, and other fruit crops.

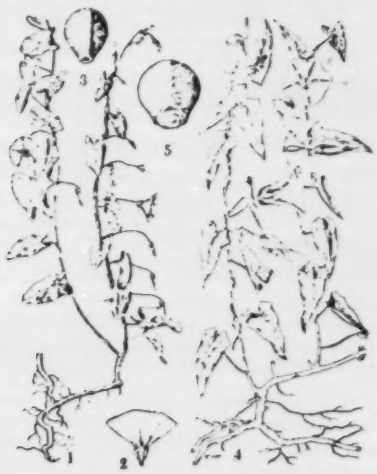
Either rainfall or irrigation is required to activate or leach the preemergence herbicide into the weed seed zone in the top soil.

Examples of postemergence herbicides used are paraquat, 2,4,5-T and the organic arsenicals, cacodylic acid and methane arsonate (MAA), or MSMA and DSMA. Spray drift to adjoining areas is of special concern because of the contact effect of paraquat, cacodylic acid, and MAA. Leaf and twig malformations are typical from 2,4,5-T. Avoid spraying these chemicals when the wind velocity is too high and the direction may cause spray drift to useful

plants and property. In citrus and peaches, paraquat application should not contact the twigs, leaves and bark of the trees.

PROSTRATE PIGWEED (*Amaranthus blitoides*). 1, lower portion of plant showing spreading habit. 2, upper part of plant with flower clusters. 3, seed. SPINY AMARANTH (*Amaranthus spinosus*). 4, portion of stem showing leaves and spines. 5, seed.

GREEN AMARANTH (*Amaranthus hybridus*). 1, upper part of stem with flower clusters and leaves. 2, flower. 3, seed. ROUGH PIGWEED (*Amaranthus retroflexus*). 4, lower stem and roots. 5, upper stem with leaves and flower clusters. 6, flower. 7, seed.



FIELD BINDWEED (*Convolvulus arvensis*). 1, part of plant showing habit. 2, flower. 3, seed. HEDGE BINDWEED (*Convolvulus sepium*, var. *americanus*). 4, portion of plant showing habit and flowers. 5, seed.

Aerial application of certain organic arsenical herbicides to Johnsongrass in cotton land is common and useful. Johnsongrass should be about 10 inches high for MSMA to be effective preplant. Cotton continues growing while the Johnsongrass dies back from a treatment of DSMA by label directions.

Susceptible grasses and weeds are controlled in sugarcane in the Rio Grande Valley. An effective postemergence s-triazine herbicide is applied to grasses competing with the sugarcane. Actually, preemergence treatments should be applied to prevent weed competition in late season.

Johnsongrass and weeds compete in pecan orchards and examples of herbicide treatments are simazine preemerge followed with dalapon postemerge on Johnsongrass.

Sunflower and pigweed are problems in grain sorghum when a preemergence herbicide is not used. If two planes work in sequence without ground flaggers, an untreated strip may result. A common mistake when using hormone-type herbicides is to add a surfactant or wetting agent to the mixture. This extra surfactant increases the effect of the herbicide on the grain sorghum and causes crop injury. Labels on these herbicides do not direct the use of extra surfactant for weed control in grain sorghum.

Several factors can cause blank heads of grain sorghum such as applying dicamba for sunflower and pigweed control after the grain sorghum is susceptible to the herbicide. Read the label carefully regarding crop tolerance and timing of treatments.

Harvest-aid treatment with dicamba for suppressing sunflowers and other weeds which germinate in late season is common in South and Central Texas and other parts of the state. Usually at this time of the year cotton is maturing, but soybeans are in a vegetative stage and susceptible to dicamba. For example, dicamba application at labeled rates cause susceptible weeds to twist downward from stem malformation.

In open areas without rows as guides, a foam marker is useful. A hose is run from the soap tank along the spray boom and dropped near the ground. The white foam mark is easily seen to the right of the front wheel toward the path of the sprayer. This marker is useful in preventing overlapping or skips in the treated area. Simazine treatment in the late fall to early spring controls weeds and grasses in a bermudagrass pasture. Simazine is not a hormone-type herbicide, but it is a very effective persistent, preemergence weed control treatment for bermudagrass pastures.

Dayflower, a rapidly growing and spreading weed even under flooded conditions, is a weed problem in rice. Control is possible with herbicides. In the second rice crop, dayflower seeds are harvested with the rice and in heavy infestations milled rice can contain the dayflower seed. This seed contamination reduces the market value of rough rice.

Because of the drift problem to corn, grain sorghum, cotton and garden and landscape plants, applicators should apply herbicides for weed control in rice when the wind is favorable and in the direction away from a crop. Surprisingly, applicators have a good safety record in applying herbicides in rice but drift damage has occurred in many cases. Flaggers are used in rice, and

uniform coverage is obtained from treatment. With herbicides, applicators can time treatments and get good weed control.

Some applicators in the Rice Belt have tried foam to reduce drift. For example, in a field where propanil + molinate was applied, the foam failed to prevent spray drift. It may have minimized the level of drift, but the wind velocity was too high for its use also. This situation illustrates that herbicide applications are generally safe from drift only if wind velocity and direction are such that it does not displace the mixture out of the field where the treatment is being made.

When wind conditions are not favorable for spraying near adjoining crops, the producer can spray several acres adjoining the crops with ground equipment. If necessary, spray the entire cut with the ground equipment. A drift area in the rice field may be left until the wind changes direction or becomes calmer.

Some leaf symptoms on grain sorghum are caused by an emulsifiable formulation of bifenox used for preemergence control of weeds in rice. The grain sorghum will recover because the herbicide is not harmful to grain sorghum; however, the solvent in the formulation causes leaves to burn. The flowable formulation of bifenox is being tested, and results show that this formulation is much less damaging to grain sorghum leaves.

Granular herbicide formulations are being developed for weed control in rice. The application rate is higher for granulars but the drift problem is nil. These formulations can be used in locations where spray drift is a problem to adjoining crops, and liquid spray can be used where spray drift is not a concern.

Harvest aid chemicals

Harvest aid chemicals are desiccants and defoliants.

Arsenic acid is a desiccant. Defoliants include cacodylic acid, tributyl phosphorothioate, tributyl phosphorothioite and paraquat.

Arsenic acid may be applied by ground equipment. Very little is applied by plane because of the corrosion from the chemical. The desiccant is applied when a high percentage of the bolls are mature. The producer cannot expect a additional boll development after the desiccant is applied because the chemical desiccates the entire plant.

When cotton is ready for stripper harvesting, desiccation is necessary for Blackland cotton production. When using arsenic acid, do not exceed the amount needed for good desiccation. Minimum levels will reduce arsenic content in fields, trash and gin dust. Studies are under way using a defoliant first and then using lower rates of arsenic acid as a follow up desiccant for stripper cotton to reduce arsenic residue and give effective desiccation.

Defoliants are applied by air and ground equipment. These chemicals give slow leaf kill and the leaves drop. Paraquat may follow the defoliant to kill regrowth in some areas of Texas. Apply defoliants at low rates early to precondition the crop and defoliate older leaves. Later follow with a full rate. Crop defoliation makes it less attractive for certain insects.

Spindle pickers are used to harvest defoliated cotton. Defoliation reduces moisture on open mature bolls, improves lint and seed quality, reduces green trash and cures the crop for easier harvesting.

## REVIEW QUESTIONS

### WEED AND BRUSH CONTROL--AGRICULTURAL

1. A plant that is a hazard, nuisance, or causes injury to man, animals or crops is called a:

   a) grass
   b) weed
   c) brush
   d) hay

2. Poor tank agitation when spraying a herbicide can cause:

   a) crop injury
   b) injury to sprayer operator
   c) weed control will be excellent
   d) damage to sprayer pump

3. Which weed is a warm season annual?

   a) pigweed
   b) johnsongrass
   c) silverleaf nightshade

4. Twenty-five pigweeds per 3 feet of row grain sorghum would cause:

   a) make no difference
   b) reduced yield
   c) provide shade for sorghum seedlings
   d) grain sorghum roots to grow deeper

5. Chemical weed control includes:

   a) preplant
   b) preemergence
   c) postemergence
   d) all of the above

6. When spraying herbicides for cropland weed control and to prevent drift, what conditions should be observed?

   a) weather conditions no problem
   b) apply with low wind to prevent drift on to other crops
   c) spray when wind conditions are highest
   d) spray when you get ready

7. When using dicamba and 2,4-D for weed control in grain sorghum, you should use:

   a) added surfactant
   b) no surfactant
   c) use any kind of cheap surfactant
   d) do not read the label

8. Herbicides are broken down by temperature and ultra violet light; another factor that aids breakdown is:

   a) high levels of soil moisture
   b) dry soil
   c) frozen soil
   d) do not apply full rate

9. Application rates on the label for control of different weeds were obtained through:

   a) trial and error
   b) no use
   c) research

10. Which are harvest aid chemicals?

   a) 2,4-D and 2,4,5-T
   b) diuron and CDEC
   c) desiccants and defoliants
   d) propanil and glyphosate

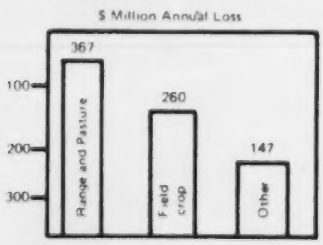
## WEED AND BRUSH CONTROL - GRASSLANDS

There are 10 vegetational areas in Texas each characterized by different kinds of plants which respond differently to various control methods. It is necessary to outline specific control practices for each area regarding woody plant problems, response of herbaceous species and range conditions for rangeland and cultivated pastures.

VEGETATIONAL AREAS OF TEXAS

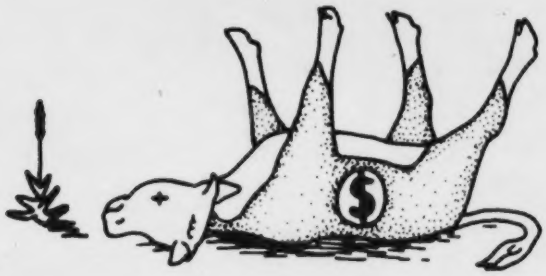
1. Pineywoods
2. Gulf Prairies and Marshes
3. Post Oak Savannah
4. Blackland Prairies
5. Cross Timbers and Prairies
6. South Texas Plains
7. Edwards Plateau
8. Rolling Plains
9. High Plains
10. Trans-Pecos, Mountains and Basins

Brush a problem on some 88 million acres of grassland in Texas, reduces potential livestock production by 50 percent causing an annual loss of more than $367 million. Areas with greater than 20 percent brush infestation generally have more than 125 trees per acre, whereas land with less than 20 percent infestation generally has less than 125 trees per acre. Proper control methods are necessary to restore rangeland productivity.




Noneconomic plants cause an annual loss of $774 million to Texas agriculture. Weeds and brush reduce forage and livestock production, increase number of cultivations, make working livestock more difficult, lower hay quality and reduce ground water yields.

Even a highly adapted cow cannot survive on native pastures void of forage plants and infested with brush and weeds.



Livestock have a difficult time surviving winters even when the land operator burns pricklypear daily. Malnutrition causes low calf crops and animals are more subject to disease. Many noxious plants either stick, sting, stink or are poisonous, causing the landownder more problems than he had just raising livestock. Noxious plants that infest grassland contribute to the annual economic loss. Productivity can be restored with proper control methods applied at the proper time followed by improved grazing management practices.

Well bred livestock, coupled with a variety of desirable forage plants, makes the livestock enterprise more profitable.

Proper planning and timing of brush and weed control practices allow a mixture of desirable forage grasses, broadleaf forbs and woody browse plants for wildlife food and cover and balanced grazing for livestock.

Plant production yield data indicate noxious plants should be controlled and replaced with more desirable species so soil moisture is used more effectively to increase production. Buffalograss produces 1 pound of dry material with only 300 pounds of water while mesquite requires about 1,900 pounds. One reason for balancing the grassland plant community is to utilize available soil moisture.

Improvement of brush and weed infested sites

Now let's consider some grassland areas before and after herbicide control practices were conducted. A Gulf Coast area was infested with weeds and macartney rose where high producing forage plants had been grazed out by heavy stocking rates. Forage production from 18 acres was needed to carry 1 animal unit during the growing season with no excess forage for winter grazing.

After 1 growing season followed by deferred grazing, the controlled area produced 5 times more forage than the untreated area. The stocking rate was increased to 1 animal unit for 5 acres with forage for year around grazing. The treated area had high producing native forage grasses while plants on the untreated area were low quality. Macartney rose had to be treated each spring with 2,4-D to control it.

A brush infested range site in the South Texas Plains had reduced the stocking rate to 1 animal unit for 40 acres. Soils which support high yields of noxious plants are capable of producing high yields from desirable forage plants and in some cases can be converted to crop production.

Following mechanical and chemical control practices using deferred grazing the treated area supported a stocking rate of 1 animal unit per 8 acres. Wildlife habitat and range condition improved greatly resulting in an overall improvement to the grassland ecosystem. The treated area had a variety of forage plants providing for yearlong grazing.

Range sites in the Trans-Pecos area are difficult to improve because a seed source of desirable plants is not present and rainfall is low and erratic. Creosotebush is difficult to control with liquid sprays. Root-absorbed herbicides such as picloram, dicamba and tebuthiuron offer the greatest possibilities for controlling this plant.

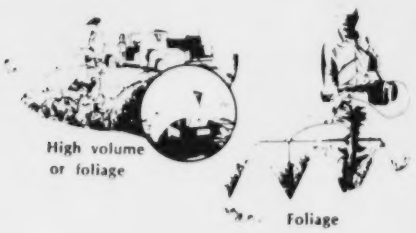
Control of the noxious plants, deferred grazing and water spreading practices restored the range site to a productive state in 3 years. In most areas of Texas reducing noxious plant populations allows native forage species to reestablish from dormant seed in the soil.

Some forbs are needed for a balanced diet in livestock. Cattle consume about 20 percent broadleaf weeds and about 80 percent forage grasses. Cattle consume only a small amount of broadleaf forbs after the plants are 6 inches or greater in height. Knowing range plants helps a commercial applicator do a better job of control by knowing what kind and amount of herbicide to apply.

When desirable forage plants are grazed out, livestock and wildlife utilize undesirable plants such as pricklypear and herbaceous weeds. As a rule these plants have little nutritive value and in some cases are toxic to grazing animals and production of useable forage is low.

Greatest forage production is realized when herbicidal treatments are made in early spring even though some weeds can be controlled in the fall with specific herbicide mixtures.

Proper timing of herbicide applications removes early growing weeds and allows later germinating forbs to produce food for wildlife and livestock. Properly time chemical weed control to produce maximum benefits with a minimum cost for herbicides. Prairie chickens have returned to some native pastures where range conditions improved.




Smutgrass is a problem on about 3 million acres of native and cultivated pastures in the eastern part of Texas. A selective herbicide, dalapon, controls smutgrass but burns other deep root perennial forage grasses reducing grazing on the treated area from 60 to 90 days depending on rainfall. Limited work indicates that dalapon can be mixed with other herbicides to obtain control of woody and herbaceous plants with one application. The amount varies from 4 pounds per acre on sandy soil to 6 pounds per acre on heavy clay soils as a foliage broadcast spray and 6 pounds per 100 gallons of water for individual plant treatment as a foliage wetting spray.

Woody plants growing on fence rows use soil moisture and reduce economic crop yield from a 25 to 100 foot strip on each side of a fence row. Leave small woody plants and herbaceous weeds along the fence row for food and cover for quail. Control large trees during the dormant season with an approved herbicide that leaves no residue in adjacent cropland soil.

Woody plants are a major problem along drainage ditches and irrigation canals. Properly used herbicides can be an economical control measure. Plants

common to these areas are macartney rose, willow, elm, oak, cattail, giant ragweed and other herbaceous weeds. Apply herbicides during the noncrop season so no residue will exist in irrigation water the following spring.

Control is all that can be expected from any method. It is virtually impossible to eradicate a plant because of the large number of seeds each plant produces such as that of a single mesquite tree. Conduct maintenance control measures before woody plants are old enough to produce seeds.

Seeds consumed by and passed through the digestive tract of animals are a major cause of reinfestation in controlled areas. Cattle moved from untreated areas to treated areas should be kept in dry lot for about 72 hours to allow seeds in the digestive system to be removed. Control woody plant seedlings with 2,4-D in spring or fall. Once a mesquite seedling plant survives the winter, it is considered an established plant and other herbicides such as 2,4,5-T, picloram/2,4,5-T mixture and dicamba/2,4,5-T mixture must be used.

Some 213 existing large mesquite trees were removed per acre in 1941 and each year stakes were placed beside new mesquite seedlings. At the end of 25 years there were 476 seedling mesquite plants removed per acre following initial control. Seeds in the soil at the time of control and ones brought by wildlife and livestock makes eradication impossible.

Results following brush control and improved livestock practices show livestock production is greater the second year and 35 percent greater the tenth year following control. Landowners may not realize economic benefits for several years following brush control practices. A return generally is realized the year herbaceous weeds are controlled with herbicides.

Wildlife such as deer, quail and other game animals and fish use grassland resources so make plans to maintain and improve their habitat. Plan for livestock, game animals and recreation so a long term brush and weed control program will benefit each and produce the greatest return from natural resources.

Water is essential for sustaining life and one should avoid contaminating water resources with herbicides.

Noxious range plants

Mesquite is the most widespread woody plant in Texas and grows in all vegetational areas except the Pineywoods. With time and specific conditions it could invade the Pineywoods. Mesquite is a legume which produces a bean crop almost every year with several crops some years. Currently, mesquite has little or no economic value. In the future it could be a valuable alternative fuel source. The extensive root system makes mesquite difficult to control. Make herbicide applications on mesquite foliage only during the spring.

Mesquite with ring of buds

A mesquite tree root crown contains underground buds that sprout rapidly following top disturbance. It is necessary that any control practice destroys the bud zone whether it is mechanical uprooting, contact killing by oil or killing by translocation of herbicides from the foliage to the root system.

Basal pouring of oil

Huisache also is a legume which grows in the Gulf Coast, South Texas Plains and lower part of Post Oak Savannah. Huisache has little or no food value for livestock or wildlife. It can be controlled in spring or fall with a broadcast spray of the translocated herbicide picloram/2,4,5-T mixture. Mechanical uprooting, diesel oil as a basal pour or trunk basal spraying with 2,4,5-T mixed in diesel oil results in high plant kill. Huisache reinfests cultivated pastures quickly and grows rapidly when the growing point is above the forage plants.

Retama is a legume that grows along the Gulf Coast and in South Texas Plains. It is a problem around livestock watering areas and streams and appears to be increasing.

Blackbrush, another legume which grows in South Texas Plains, is most abundant on shallow range sites. A broadcast application of the translocated herbicide picloram/2,4,5-T mixture in the spring or fall produces excellent control. Picloram pellets applied in the fall or winter also produce excellent plant kill. Blackbrush provides protection for desirable forage plants so range recovery is rapid following herbicidal control. Leave dead blackbrush plants standing for wildlife cover.

Granjeno or spiny hackberry is a problem on South Texas ranges. It reinfests areas rapidly following mechanical control. It also is a problem in cultivated pastures; however, granjeno berries are excellent game bird food. Spring or fall application of translocated herbicide picloram/2,4,5-T mixture produces excellent plant kills. Some dry herbicides which are root absorbed, produce good plant kills. Individual treatment using 2,4,5-T mixed in diesel gives good results.

Macartney rose infests about 500,000 acres of very productive soils throughout the Gulf Coast and eastern part of Texas. It is difficult to control because it is a root sprouter and herbicides do not translocate throughout the entire root system. Livestock consume rose hips in late summer and fall and distribute the seeds in the feces throughout the pasture causing heavier reinfestations. Macartney rose requires a herbicide treatment, fire or mechanical practice at approximately 18-month intervals to maintain control. Picloram pellets or picloram/2,4,5-T mixture produces longer control than other herbicides. Once the initial infestation is controlled, the area can be maintained with periodic herbicide treatments.

Whitebrush is a problem in parts of the Rolling Plains, Edwards Plateau, Gulf Coast, Trans-Pecos and South Texas Plains and grows on the more productive soils. Many whitebrush sites can be converted to cultivated pastures or cropland through mechanical control methods. Of the approved herbicides, picloram pellets, a root absorbed herbicide, produces effective plant control. Tebuthiuron, not currently approved, appears to be the best herbicide for control as less active herbicide is applied per acre than other herbicides.

Soil surface

Sand shinnery oak grows abundantly on sandy sites in the High and Rolling Plains and Trans-Pecos

areas. Range condition recovery is rapid following broadcast control with silvex or 2,4,5-T. Treat sand shinnery oak when density is sufficient to reduce forage production. Limestone shin oak in the Edwards Plateau is more difficult to control. Reduce limestone shin oak growth by mechanical methods or heavy grazing with goats; then allow plants to regrow and treat the new growth with a foliage herbicide in the spring. Results from treating undistrubed shin oak with foliage herbicides is unsuccessful. Shin oaks are poisonous in the bud stage but after full leaf development they can be consumed by animals. Control oaks adjacent to cotton fields to reduce the overwintering habitat of destructive insects.

Sand sagebrush is a major problem on sandy soils in the Rolling and High Plains and Trans-Pecos areas. Broadcast application of 2,4-D at 4- to 5-year intervals is presently the most economical treatment. It is suggested that about 25 percent of the sagebrush be maintained to reduce soil erosion by wind.

Chemical control is preferred over mechanical control for yucca, a root sprouter and a serious problem on some range sites in the Texas Panhandle. Silvex or 2,4,5-T as a broadcast foliage spray gives effective results. Apply in spring when plants are in 2/3 to full bloom stage. It requires at least two growing seasons following spraying before all plants die. Individual plant treatment with 2,4,5-T mixed in diesel oil with the mixture applied on the crown produces excellent control. Individual plant treatment can be made anytime during the year. Delay maintenance treatments for about 4 years following initial control to allow roots to sprout.

Baccharis or dryland willow is rapidly becoming a major problem from central Texas to the east, particularly along streams and in old cultivated fields. Baccharis has no value. Broadcast foliage sprays with 2,4-D low volatile ester in spring or fall produce good control. Latest research shows that 2,4-D low volatile ester produces better control than other herbicides tested.

Cholla is most abundant in Trans-Pecos, High Plains and Rolling Plains. Mechanical grubbing or use of a broadcast foliage spray with picloram/2,4,5-T mixture or 2,4,5-T mixed in diesel oil as individual plant treatment produce effective control. Some cholla plants have nutlets on the root system which sprout when tops are disturbed. Cholla plant joints broken off and in contact with the soil usually take root and establish a new plant.

Tasajillo, or turkey pear, can be a problem in any area except the Pineywoods. The fruits are excellent wild turkey food. Broadcast foliage spraying with picloram/2,4,5-T produces excellent control. A foliage applied mixture of 2,4,5-T and diesel oil or picloram pellets used as individual plant treatment also produce good control.

Pricklypear grows in every area of Texas but is a greater problem in the southern and western part of the state. Broadcast spraying with picloram/2,4,5-T mixture at 1 pound per acre gives good results. Two growing seasons following control are required before all plants die. Control scattered pricklypear using a foliage spray 2,4,5-T mixed in diesel oil or picloram pellets as individual plant treatments. Three to five pellets per square foot have produced satisfactory control. Pricklypear can be used as an emergency

livestock feed. Wildlife will consume pricklypear when other green feed is scarce. Design control programs to maintain some pricklypear.

Oaks and other hardwood species are a problem in the Post Oak Savannah. Oak control is not encouraged because these woody plants can be used for fuel. Oak sprouts are a major problem in cultivated pastures. Control sprouts with broadcast application of 2,4,5-T or picloram/2,4,5-T mixture. Picloram pellets and tebuthiuron show promise for controlling oak sprouts. Range condition recovers rapidly when oaks are controlled with herbicides.

Yaupon is an underbrush species in the Post Oak Savannah and Pineywoods. It is difficult to control but root absorbed picloram pellets produce effective control. Yaupon is browsed by livestock and deer, and berries are excellent food for wild birds. It belongs to the holly family and is used as an ornamental.

Texas persimmon, or black persimmon, is a root sprouter and a severe problem in the eastern half of the Edwards Plateau. Wildlife relish the ripe black fruits. Individual plant treatment with 2,4,5-T mixed in diesel oil and applied from July to March or root absorbed pellets applied in winter produce effective control.

Common or eastern persimmon grows in the eastern part of Post Oak Savannah and Pineywoods. It is a major problem in cultivated pastures. Dicamba applied as a broadcast foliage spray or used as a root absorbed granular at the rate of 1 teaspoon of material per inch of stem diameter produces good control. Common persimmon fruits are edible.

Mescalbean or mountain laurel is a poisonous plant most abundant in the lower part of Edwards Plateau. Individual plant treatment using 2,4,5-T mixed in diesel oil is effective. Root absorbed herbicides may offer a good control method since mescalbean grows on steep slopes where it is difficult to treat with liquid herbicides.

Coyotillo is another poisonous plant growing in the Edwards Plateau and South Texas Plains. Individual plant treatment with 2,4,5-T mixed in diesel oil and following effective rainfall is an effective control method. Dry herbicides offer the landowner a faster method of individual plant treatment.

Lotebush, bluewood or chaparral, is a root sprouter and can become a problem following control of overstory woody species. Lotebush berries are excellent wildlife food and the bushes are excellent cover for quail. Individual basal plant treatment with 2,4,5-T and diesel oil or root absorbed pellets produce effective control.

Catclaw acacia and catclaw mimosa, both called "wait-a-minute" bush, are problems on some sites in the Edwards Plateau, High and Rolling Plains and Trans-Pecos areas. Broadcast foliage application with picloram/2,4,5-T mixture or individual plant treatments with 2,4,5-T mixed with diesel oil or picloram pellets produce effective control. In the Trans-Pecos, dicamba/2,4,5-T mixture applied in a broadcast foliage application has produced satisfactory results.

One or more of the junipers--redberry, blueberry or eastern red--are problems in most areas of Texas. Control redberry juniper with root absorbed pellets

or mechanical uprooting. It requires high rates of root absorbed herbicides to control blueberry juniper but mechanical slashing is very effective. Harvesting eastern red cedar for lumber rather than controlling it is encouraged.

Salt cedar is a major problem along streams and rivers in the Rolling and High Plains and Trans-Pecos areas. No satisfactory control methods using herbicides exist. Also, herbicide residues in water sources restrict chemical use.

Herbaceous weeds can be a problem on any site in any given year. Broadcast application of 2,4-D or dicamba/2,4-D mixture produces excellent control on young weeds.

Croton, dove weed or goat weed, grows on sandy soils but germinates later in the spring than some herbaceous weeds. Croton is excellent bird food. Plan weed control operations to control unwanted plants while keeping beneficial ones.

Sunflowers can be a problem even though they supply much food for birds. Ashe sunflower on the Gulf Coast is difficult to control because of heavy growth of fine hairs on the leaves. Usually 2,4-D produces excellent control. If perennial weeds occur with sunflowers, it may be necessary to use dicamba/2,4-D mixture.

Cocklebur, a poisonous plant, is easy to control with 2,4-D. Cocklebur is most abundant in disturbed soil areas and around livestock watering areas. Cockleburs can cause livestock injury and reduce wool and mohair prices.

Bitter sneezeweed is a summer annual growing in the eastern half of Texas. Broadcast applications with 2,4-D when the plants are less than 6 inches tall produces effective results.

Western bitterweed is a winter annual and toxic to sheep and sometimes to goats. Bitterweed germinates in fall following adequate moisture in late summer and early fall. Broadcast spraying must be done at bud stage before plants bloom to obtain good plant kill and prevent production of viable seed. Bitterweed has to be sprayed before most other weeds have made rapid growth. Results are unsatisfactory when soil is saturated with moisture or plants are in slight drouth stress.

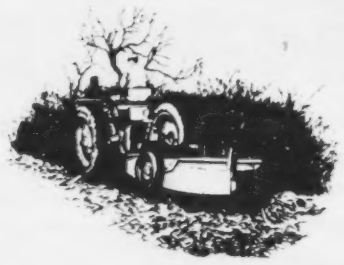
Annual broomweed is a problem when sufficient fall moisture causes germination in October and November. Broomweeds are a problem where there are 4 to 8 seedings per square yard. Broomweed has little value for wildlife food. Broadcast spraying with 2,4-D produces excellent plant kills. Spray when broomweeds are about 6 inches tall and before croton and snow-on-the-mountain germinate. The two latter plants supply much food for game birds.

Perennial broomweed, snakeweed or broom snakeweed, is a toxic plant to cattle in the western half of Texas. Broadcast spraying with picloram/2,4,5-T mixture in the spring or fall produces excellent plant kills. Dicamba/2,4,5-T mixture gives erratic control but spring treatments are better than fall ones. Spray in spring when plants are 2/3 to full leaf while the fall application should be made following adequate rainfall to produce added weed growth.

Spray coneflowers and nightshades when they are young and less than 6

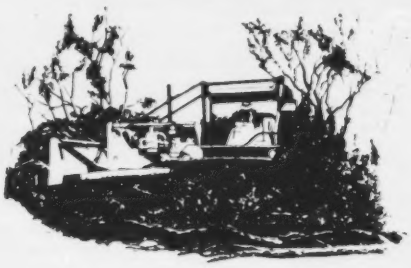
inches tall. Dicamba/2,4-D, dicamba/2,4,5-T, and picloram/2,4,5-T produce good results on these hard-to-kill perennial weeds.

Methods of control

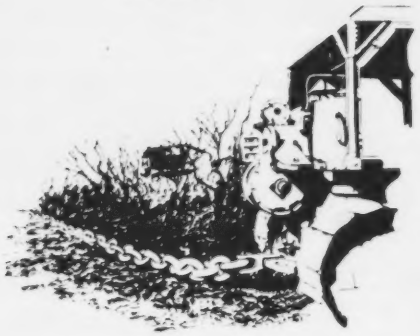


Shredding

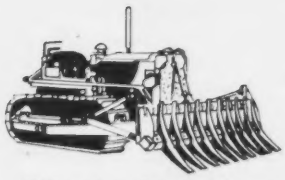
Methods of brush and weed control on grasslands include mechanical, chemical, biological and fire. Use each method properly to produce satisfactory control of a particular species.



Bulldozing



Chaining



Heavy-duty brush rakes, rock rakes, root rakes

When a seed source of the more desirable forage plants are present, range improvement is rapid following control coupled with deferred grazing. One or two plants per 100 square feet of desirable forage species allows natural reestablishment of native forages.

Forage production can be 13 times greater than in untreated areas. In such a situation the landowner can expect a return on the investment the first year following control.

Good weed and brush control depends on good application using the method best suited for a particular weed problem on a specific site.

Herbicide application

Weather conditions, wind speed and direction, humidity, temperature and air stability all determine the amount of herbicide mixture deposited on the target area. Wind speed and direction and air stability may be the most important factors affecting broadcast application and causing physical drift of herbicidal spray from target areas. Do not apply liquid sprays when fog is present. Discontinue spraying when air temperature reaches 95° F or when heating causes convective thermals allowing spray particles to drift from target area. Place wind gauges with the flagmen and at the mixing truck.

A hand held wind gauge which is accurate and inexpensive is good insurance for any spraying operation. Other more expensive wind gauges can be purchased but generally require extra time to calculate wind velocity.

To determine presence of temperature inversions use a method which you have found to work satisfactorily. A temperature inversion is considered to be the most troublesome weather factor for the aerial applicator. It consists of a layer of cool air at ground level and warm air up to a certain height, then air gets cooler. Spray droplets will not move above the upper cool layer and will drift with the prevailing wind.

Plant growth conditions are as important as weather conditions for controlling noxious plants. Probably more unsatisfactory results and landowner dissatisfaction result from applications made when plants are in the wrong growth stage. For example, individual plant treatment of woody plants with a specific liquid herbicide must be made at certain seasons for greatest control. *Cut surface*, placing herbicide mixture in frill or on stump, can be done throughout the year but discontinue *trunk basal bark* spraying when woody plants are leafing out or going dormant. *Foliage* spraying with some herbicides must be made in spring after plant leaves are fully developed, growing actively, replenishing root food reserves and have adequate soil moisture. Plant kills are greatest from *dry herbicides* when they are applied during the dormant season. Rainfall moves the herbicide into the root zone where the plant takes up the chemical when it foliates. Exposure to long periods of sunshine and hot dry soils reduces the effectiveness of dry herbicides. For example, about 100 percent of whitebrush plants can be killed with 3 pounds per acre active ingredients of picloram pellets when applied from October to April while less than 20 percent are killed when pellets are applied from June through September.

Frill

Spraying cut stump

Spraying on trunk base

Notch

Mesquite can be classified as the most tempermental, unpredictable woody plant to kill. Growth begins in late March with greatest stem growth during April. As stem growth stops and leaves begin to mature, trunk growth starts with greatest growth occurring during late May and June. Research, demonstrations and commercial application results indicate that foliage-applied herbicides should be made during May and early June or about 2 weeks after leaves change color from light yellow to dark green. Average length of the optimum foliage spraying season is about 50 days. As a general rule do not start foliage applications earlier than 40 days after green growth is noted in the spring or later than 90 days after growth. Consider foliage color, plant growth, soil moisture and temperature before making an application. Soil temperature should be about 70° F for the plants to produce most active growth. Sufficient soil moisture is needed to produce rapid plant growth for at least 30 days before spraying. In some areas, particularly the Gulf Coast and South Texas Plains, mesquite trees do not react in growth patterns as uniformly as in other areas of Texas. Judgment of a commercial applicator based on past experiences is the best criteria for determining when to start and stop herbicide application. The following statements about foliage application of herbicides for mesquite control are based on years of field observance during wet and dry years, as well as other kinds of plant growth conditions.

Encourage a control program where 10 to 15 percent of the mesquite-infested acreage is treated each year. This program will continue for many years.

Base the brush control program on forage production rather than on plant kills.

Greater than average plant kills have been obtained following drought years when above average, late winter moisture produced excellent plant foliage and the rainfall stopped in May allowing maximum foliage and plant growth for ideal spraying.

Plant kills appear greater than average during the year following production of a heavy bean crop with the summer and fall months dry, preventing the mesquite from fully restoring the food reserves in the root system.

Less than average plant kills are obtained when rainfall continues throughout the 50-day spraying season allowing mesquite stems and foliage to continue growing. Applications made too early or too late or when foliage is damaged by insects, hail or frost produce unsatisfactory plant kills.

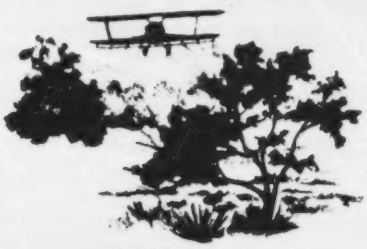
The amount of diesel oil in the standard volume mixture can be reduced by about 1/3 at the beginning of the spray season and increased by 1/3 at the end of the season. This variation allows for the difference in the tenderness, and amount of wax on the mesquite leaves. Do not vary the amount of oil when the low volume technique is used.

Water mixed with herbicides should not contain high salt levels which may cause the herbicide to precipitate resulting in poor plant kills. Good water is very important when using amine formulations.

Mesquite growing on heavy clay soils can be treated later than trees growing on upland clay or sandy loam soils.

Application--equipment and techniques

Where it is difficult to build air strips, the helicopter is well adapted for applying liquid and dry herbicides. No difference in plant kills is evident when herbicides are applied by rotary or fixed wing aircraft.



AERIAL SPRAYING

Fixed wing, single engine aircraft varying from 150 to more than 800 horsepower are well adapted for brush work in Texas while multi-engine aircraft can be used to apply chemicals to large acreages. Commercial applicators generally select the kind of aircraft best suited for their particular area of operation.

Commercial applicators select sprayer equipment such as pumps, nozzles, orifices, gauges and mixing and loading equipment which they feel will do the best job. Locate a pressure gauge on the boom where it can be read from the cockpit as well as a gauge mounted in the cockpit. The most commonly used nozzle is the diaphram. It requires about 12 to 15 pounds pressure to open the valve for proper flow of herbicide mixtures.

A diaphram nozzle contains orifice, screen, whirl plate and diaphram. Adjust the nozzle on the boom to insure positive cut off.

A flapper nozzle generally operates with a lower pressure than the diaphram nozzle. The flapper nozzle was first used to determine whether a lower gallonage of solution could be used and still obtain satisfactory coverage and plant kill and reduce physical drift. It is one of the first nozzles developed for aerial application and is still recognized by many as the best nozzle for herbicide application in brush control.

A flapper nozzle has a screen and an orifice and is cut off by a spring-loaded flapper and opened with a small steel cable.

The low volume technique developed by Texas Agricultural Experiment Station research personnel reduces wing vortex action and physical drift. Place the last nozzle on the boom at least 3 feet from the end of the aircraft wing tip, or the last nozzle on the boom should not extend beyond the last third of the length of the aileron. This nozzle arrangement reduces wing vortex and swath-width.

Applicators using the low volume, low pressure technique for applying herbicides should follow certain specifications in equipping their aircraft and making herbicide applications.

- Allow a maximum spraying pressure of 15 pounds.
- Maintain constant agitation in the tank.

- No more than 20 nozzles on the boom of a regular single engine aircraft.
- Place outside nozzle 3 feet from the wingtip.
- Deflect nozzles no more than 45° from the chord line of the wing.
- Remove whirl plates when diaphram-type nozzles are used.
- Release spray material within 10 feet of the target plants.
- Do not exceed the total width of the wingspan for swath. When spraying tall dense brush one may need to reduce swathwidth by 10 percent.
- Cease spraying when ambient air temperature exceeds 90°F.
- Spraying operations near susceptible crops (cotton, vegetables and ornamentals) must conform to the following table:

| Wind velocity | Downwind | Upwind |
|---|---|---|
| 0 to 3 mph | 1 mile | 1/2 mile |
| 4 to 6 mph | 2 miles | 1/8 mile |
| 7 to 10 mph | 4 miles | 250 feet |

When spraying adjacent to bodies of water, these distances do not apply. Bodies of water do not provide a distance barrier.

Calibrate the equipment by flying into and with the wind over a measured distance at the airspeed you intend to use during application. Make sufficient passes to determine calibration.

To determine swathwidth and droplet size and distribution, spray over photographic contact paper or use adding machine tape. Adding a dye to the water enables greater visibility of droplets on the paper. Fly over the tape at a right angle using the airspeed and height that will be used during actual application. To determine accurate swathwidth for spraying brush, make final calculations within the woody plant stand. This method also applies when spraying brush with ground equipment using boomless nozzles.

Place the tape on a metal slide or on the ground if surface and vegetation are dry.

Cut the tape into segments and attach to a board. Number each segment from the center outward on each side of the aircraft flight path.

Droplet size and distribution should be about the same with 1 gallon per acre as with 4 gallons per acre, but there will be fewer droplets with the 1 gallon per acre application.

Droplet tapes can be folded and used for future checking after the droplets have dried on the paper.

Conduct calibrations for dry and liquid herbicides in a similar manner. Use containers large enough to obtain a satisfactory sample and deep enough that the pellets will not bounce from the container.

After equipment is calibrated continue to weigh or measure the amount of material before and after application so accurate rates per acre can be determined.

The flagman is the most important person of the ground crew. Flagmen need experience in accurately measuring swathwidths. Start application on the downwind

side and move into the wind. Flagman should start measuring the next swath when seeing or hearing the aircraft. This keeps the flagman from being sprayed with the herbicide. Spraying into the wind prevents flying through spray droplets released during the previous swath. It is more desirable to spray with a crosswind than with wind parallel to the spray plane.

Use flagpoles of nonconductive, easy to handle material. A fiberglass telescopic pole works well as it can be raised or lowered depending on the height of the brush. The flag should not extend more than about 5 feet above the tops of woody plants. If the flag extends too high, it blends in with the sky and is difficult to see. Flagmen should move the flag from side to side in a slow motion so the pilot can site the next swath. Station flagmen 1/2 to 1 mile apart to allow the pilot to fly a straight path for accurate and complete coverage of target plants.

One type of mixing rig and loading equipment with four tanks and an "Aframe" hoist allows liquid or dry material to be loaded into the aircraft. The rear tank is used for mixing while the other tanks contain water, diesel oil or aviation fuel.

A transport tank can be partitioned for water and diesel oil for mixing liquid herbicides. Aviation fuel is supplied from a separate tank on another vehicle. Some commercial applicators have metering devices for measuring herbicide, oil and water in proper amounts with mixing taking place in the pump as the formulated emulsion enters the loading hose.

Research personnel have used 55-gallon barrels to develop mixing equipment for experimental plot work. By turning a valve, the solution can be drained from each barrel.

Mixing crews should have a batch mixed and ready for loading while the aircraft is spraying a load. The sprayplane should not be on the ground over 5 minutes from the time of touch down until take off.

The loading pump and hose should deliver large volumes to minimize downtime while loading the aircraft.

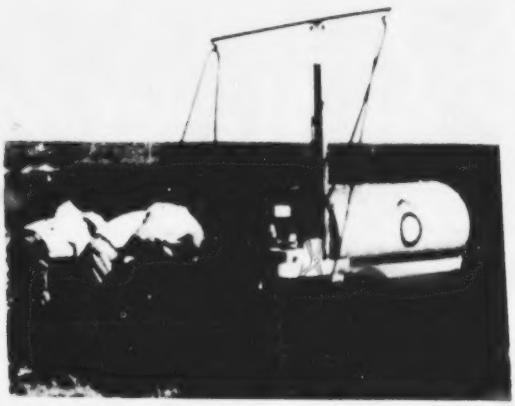
After standing for 12 hours the oil-water-herbicide emulsion begins to separate but minimum agitation will return it to a proper emulsion. Use batch mixing or metering devices for mixing oil-water-emulsion rather than mixing a transport tank full.

With less emulsifier more separation of oil-water-herbicide emulsion occurs. In mixing an oil-water-herbicide emulsion using low volatile ester, mix the herbicide and oil together and add to the water with agitation. For an amine, mix the herbicide with the water, add an oil emulsifier to the oil and then add the oil to the herbicide-water solution using vigorous agitation. An oil-water-emulsion with low volatile ester will be a creamy white while the emulsion with an amine can be slightly brownish. The kind of water and grade of diesel oil also affects the color and stability of the emulsion.

Spraying an oil-water-herbicide emulsion at 4 gallons per acre in 7 mph crosswind, allows spray to settle to the ground with some side drift displacement.

Areas with heavy forage growth around low growing plants should have the forage removed by concentrating grazing animals for a short period. Heavy forage grass cover prevents spray droplets from contacting the foliage of target plants.

Ground sprayers which apply solution to individual plants should have an attachment to keep hoses off the ground and make spraying less tiring for the operator.



Hoses off the ground

Use foliage wetting sprays when plants are growing actively. Up to 500 gallons per acre of solution are needed for complete coverage on all plants. This method is best adapted to treating brush and weeds along fence rows. Equip the hand gun with a No. 6 or 8 orifice and use with low pressure to prevent spray drift.

A hand boom sprayer is well adapted for lawns, industrial areas and golf courses. A 40-inch long hand boom held 20 inches above the target plants delivers an effective 60-inch swath.

Air blast and mist blower sprayers have limited use for applying herbicides because of small droplets created by the air fan. Add drift control agent to reduce downwind drift. Specific instructions for use in the Pineywoods are outlined by the Texas Department of Agriculture regulations.

Foliage

If physical drift causes no problem, the *wide swath* or *boomless* type sprayer nozzle on a ground sprayer can be used. This particular sprayer has the same limitation as the air broadcast. Even with limitations, it is best suited for applying herbicides to low growing, woody plants and spraying over rough terrain.

Ground sprayer operators can travel together to reduce the number of flagmen required.

A boom broadcast sprayer mounted on a "Big A" is equipped with a low and a high boom. A foam nozzle at the tip of the boom is used to mark the swath eliminating the need for flagmen.

When spraying adjacent to susceptible crops or residential areas, use a drift control agent to reduce physical drift.

It is essential that sprayers are equipped with pressure regulators which work easily so rapid and accurate pressure changes can be made.

Check pressure gauges to determine if they are working satisfactorily and registering the correct pressure. For most broadcast spraying equipment 20

to 40 pounds is sufficient to deliver the proper amount of mixture and produce desired droplet size.

Coastal bermudagrass and other cultivated pasture grasses become established more rapidly when the proper amount of simazine per acre is applied at time of sprigging or planting to control competing vegetation. Annual broadleaf weeds and annual grasses compete heavily with bermuda during the first growing season. Simazine can be applied the second year to a partially established stand.

Applying simazine at the proper time assures maximum high quality hay production. Most broadleaf weeds are controlled except nightshades. Picloram/2,4,5-T mixture controls nightshades and most woody and broadleaf plants. A dicamba/2,4-D mixture can be used to control hard-to-kill annuals and perennial broadleaf plants.

Apply simazine and diuron with a *boom-type sprayer* using 25 to 35 gallons of water per acre to obtain even coverage of the sprayed area. If the boom is set too high or too low, insufficient coverage results and weedy grasses continue to grow. Each sprayer nozzle should deliver the proper amount of herbicidal spray.

The cluster jet or boomless nozzle which is popular for spraying rough pastures and rangeland is not suitable for applying simazine on a coastal bermudagrass establishment because of insufficient coverage of the soil surface with herbicidal spray.

Drift control

Physical drift from the target area is one of the greatest hazards of using herbicides. When there is no danger of physical drift from the target area, standard spray solutions and equipment can be used.

A drift control agent added to the spray solution increases droplet size and reduces fine particles from shearing when the solution goes through the nozzle. Drift control agents create added expense but, in most cases, are good insurance. Drift control additives are good wetting agents.

A hooded sprayer is a low volume, low pressure system which can use undiluted herbicides or herbicides mixed in oil. The herbicide is released beneath the hood eliminating almost all physical drift. Application with this equipment can be made through the day. Spraying with the equipment produces effective control for herbaceous weeds and woody plants up to 3 feet tall.

Physical drift is generally greater when herbicidal sprays are applied from aerial equipment. Drift control additives reduce drift. Locating the outer nozzle of the boom at least 3 feet from the wing tip helps reduce vortex drift. Proper orientation of nozzles and low pressures also aid in reducing drift.

Making applications when acceptable spray conditions can be met greatly reduces physical drift.

Reduce physical drift from aerial application by using specially designed booms and attachments to deliver invert emulsions. The "microfoil boom" is only one example of this type of sprayer equipment.

When a drift control additive is used, more solution per acre is required to obtain adequate coverage. When spraying adjacent to cropland or on industrial sites, use a drift control additive.

Summary

To determine which herbicide to use for economical and effective plant control, consider some woody plant growth conditions. Spray a pure stand of mesquite with 2,4,5-T/oil/water emulsion using a standard volume of 4 gallons per acre or a low volume of 1 gallon per acre. Generally, landowners with pure mesquite want the most economical application. If the area contains perennial weeds or mature annual weeds, dicamba/2,4,5-T mixture is a better choice.

In an area containing mesquite, huisache, pricklypear, granjeno and herbaceous weeds spray with picloram/2,4,5-T mixture for maximum control of all noxious plants.

For a mixed brush area use the maximum amount of picloram/2,4,5-T mixture. A follow up treatment usually is necessary in 4 to 5 years to control regrowth and maintain a proper mixture of plants for livestock and wildlife.

A pure stand of post and blackjack oaks can be controlled effectively with 2,4,5-T or silvex. If the underbrush species are yaupon, haws, winged elm and other oaks, add picloram/2,4,5-T mixture for improved total plant control. Two successive yearly applications are required for satisfactory oak control. Within 3 to 5 years following initial control, the area can be chained and burned. Then initiate a maintenance control program to control sprouts and new seedlings.

Treat sand shinnery oak in the Rolling Plains with silvex or 2,4,5-T for maximum range recovery. The taller shinnery oaks will not be controlled as effectively as smaller ones.

Sand sagebrush in the High and Rolling Plains areas can be controlled effectively with a broadcast application of 2,4-D. Herbaceous weeds must be controlled before production from desirable forage plants increase or range condition improves.

Woody plants growing along fence rows can be controlled effectively with dry herbicides such as picloram pellets. Picloram pellets will not control mesquite because the root system will not absorb this herbicide.

Begin maintenance control practices as soon as regrowth is noticeably taller than forage plants. Several herbicides and methods can be used.

Proper use and timing of herbicides can maintain grassland ecosystems.

## REVIEW QUESTIONS

### WEED AND BRUSH CONTROL--GRASSLANDS

1. Smutgrass is a problem in the eastern part of Texas. It can be controlled with:

   a) 2,4-D
   b) dalapon
   c) 2,4,5-T
   d) dicamba/2,4,5-T mixture

2. To improve sand shinnery oak infested area, what method would you use?

   a) broadcast spray with 2,4,5-T or silvex in the spring
   b) individual plant treatment using 2,4,5-T mixed in diesel oil
   c) graze the pasture with large number of cattle when oak is in bud stage
   d) plow up the area and plant soybeans

3. Oak sprouts in cultivated pastures can be kept under control by broadcast spraying with:

   a) 2,4,5-T or picloram/2,4,5-T mixture
   b) 2,4-D amine
   c) bromacil
   d) dalapon

4. How would you check to determine the rate per acre of picloram/2,4,5-T mixture to use and how to mix the herbicide?

   a) call herbicide specialist of TDA
   b) call registration dividion of EPA
   c) read and follow instructions on EPA approved label on herbicide container
   d) wait until next week when chemical salesman will be in the area

5. When using low volume technique for aerial broadcast spraying the last nozzle on the boom should be no closer than _____ feet to the wing tip.

   a) 5
   b) 3
   c) 8
   d) 1

6. A herbicide application to foliage of mesquite using 2,4,5-T, dicamba/2,4,5-T mixture or picloram/2,4,5-T mixture must be made:

   a) during the fall
   b) during late summer
   c) during the spring

7. Plant kills of susceptible plants are greatest from use of dry herbicides when applied:

   a) after rainy season
   b) in dormant season prior to rainfall
   c) in summer only
   d) in any season

8. Distance the herbicide spraying operation should be from susceptible plants downwind with wind speeds of 0-3 mph:

   a) 1 mile
   b) 2 miles
   c) 3 miles
   d) 4 miles

9. Drift control additives are used to reduce physical drift but also are good:

   a) fire retardants
   b) wetting agents
   c) add nothing to mixture
   d) reduces wear of nozzle orifice

10. Simazine and diuron should be applied with a boom type sprayer using:

   a) 5-10 gallons per acre
   b) 50-60 gallons per acre
   c) 25-30 gallons per acre
   d) over 60 gallons per acre

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3M–3-77, Revision
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